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METEORITES.

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Meteorites come from meteors. Meteors are large shooting stars. Shooting stars may be seen on almost any clear, moonless night, the number visible to a close observer being usually about four or five an hour. They are liable to appear in almost any quarter of the sky and usually vary in brilliancy and color. In addition to the ordinary shooting stars there are certain periods of the year when much larger numbers are to be seen, producing what are called star showers. Two of the best known and typical of these showers occur early in August and about the 13th of November. These are known as the August and November meteors, or as the Perseids and Leonids, these latter names being given them because the meteors seem to come in the one case from the constellation of Perseus and in the other from that of Leo. This does not mean that they actually originate in those constellations, but simply that they are in the line of sight between us and them. The paths of the falling stars of these showers are, as a whole, parallel, showing that they come from one region of space, but individuals often exhibit curved and zigzag paths. This glancing and deflection of movement is regarded as proof that the substance of the individual meteors is solid. The amount of substance in the individuals is however believed to be very small. Calculated from the energy represented by the light which they give forth, it is believed in the majority of cases that the amount of matter constituting the individual meteors would weigh scarcely more than a grain. The individuals of the Perseid showers are yellowish and move with medium velocity; the Leonids are greenish or bluish and move very swiftly,

for we meet them head on; while the Andromedes are sluggish in movement and red in color. Recurring, as they do, annually, the shooting stars of these groups are believed to move in elliptical orbits.

Passing apparently by all gradations from the usual shooting stars come the large meteors, known also as bolides or fireballs. These are of much less common occurrence than the shooting stars and naturally attract more attention when they do occur. Their brightness is often such that they can be seen over large areas of country and their passage is often accompanied by loud reports and detonations which are widely observed. From many of them no solid body falls to the earth, but occasionally a stone or iron comes from them. Such are the stones we call meteorites. The phenomena attending the fall of a meteorite are therefore practically those of large meteors. Of such phenomena we have a very graphic account in that of the fall which took place at Homestead, Iowa, at about ten o'clock on the evening of February 12, 1875. The movement of this meteor was north and east, its northward course being 112 miles in length and the eastward one 47 miles. This entire distance was traveled in about ten seconds, so that the velocity of the stones, including their retardation by the air, was at least 15 miles per second. The phenomena are described by C. E. Irish, a civil engineer of Iowa City, as follows: "From the first the light of the meteor could hardly be tolerated by the naked eye turned full upon it. Several observers who were facing south at the first flash, say that upon looking full at the meteor it appeared to them round, and almost motionless in the air, and as bright as the sun. Its light was not steady, but sparkled and quivered like the exaggerated twinklings of a large fixed star, with now and then a vivid flash. To these observers, all of whom stood near the meteor's line of flight, its size seemed gradually to increase, also its motion, until it reached a point almost overhead, or in a direction to the east or west of the zenith, when it seemed to start suddenly, and dart away on its course with lightning-like rapidity.

"The observers who stood near to the line of the meteor's flight were quite overcome with fear, as it seemed to come down upon them with a rapid increase of size and brilliancy, many of them wishing for a place of safety, but not having time to seek one. In this fright animals took part, horses shying, rearing and plunging to get away, and dogs retreating and barking with signs

of fear. The meteor gave out marked flashes in its course, one more noticeable than the rest, when it had completed about two-thirds of its visible flight. All observers who stood within twelve miles of the meteor's path say that from the time they first saw it, to its end, the meteor threw down 'coals' and 'sparks.'

"Thin clouds of smoke or vapor followed in the track of the meteor and seemed to overtake it at times, and then were lost. These clouds or masses of smoke gave evidence of a rush of air with great velocity into the space behind the meteoric mass. The vapor would seem to burst out from the body of the meteor like puffs of steam from the funnel of a locomotive, or smoke from a cannon's mouth, and then as suddenly be drawn into the space behind it. The light of the meteor's train was principally white, edged with yellowish green throughout the greater part of its length, but near to the body of the meteor the light had a strong red tinge. The length of the train was variously estimated, but was, probably, about 9°, or from seven to twelve miles, as seen from Iowa City. The light about the head of the meteor at the forward part of it, was a bright, deep red, with flashes of green, yellow and other prismatic colors. The deep red blended with and shaded off into the colors of the train at the part following; but the whole head was enclosed in a pear-shaped mass of vivid white light next to the body of the meteor, and the red light fringed the white light on the edges of the figure, and blended with it, on the side presented to the eye.

"From three to five minutes after the meteor had flashed out of sight, observers near the south end of its path heard an intensely loud and crashing explosion, that seemed to come from the point in the sky where they first saw it.

"This deafening explosion was mingled with, and followed by, a rushing, rumbling and crashing sound that seemed to follow up the meteor's path, and at intervals, as it rolled away northward, was varied by the sounds of distinct explosions, the volume of which was much greater than the general roar and rattle of the continuous sounds. This commotion of sounds grew fainter as it continued, until it died away in three to five explosions much fainter than the rest.

"From one and a half to two minutes after the dazzling, terrifying and swiftly moving mass of light had extinguished itself in five sharp flashes, five quickly recurring reports were heard. The volume of sound was so great that the reverberations seemed

to shake the earth to its foundations, buildings quaked and rattled, and the furniture that they contained jarred about as if shaken by an earthquake; in fact, many believed that an earthquake was in progress. Quickly succeeding, and in fact blended with the explosions, came hollow bellowings, and rattling sounds, mingled with a clang, and clash and roar, that rolled slowly southward as if a tornado of fearful power was retreating upon the meteor's path."

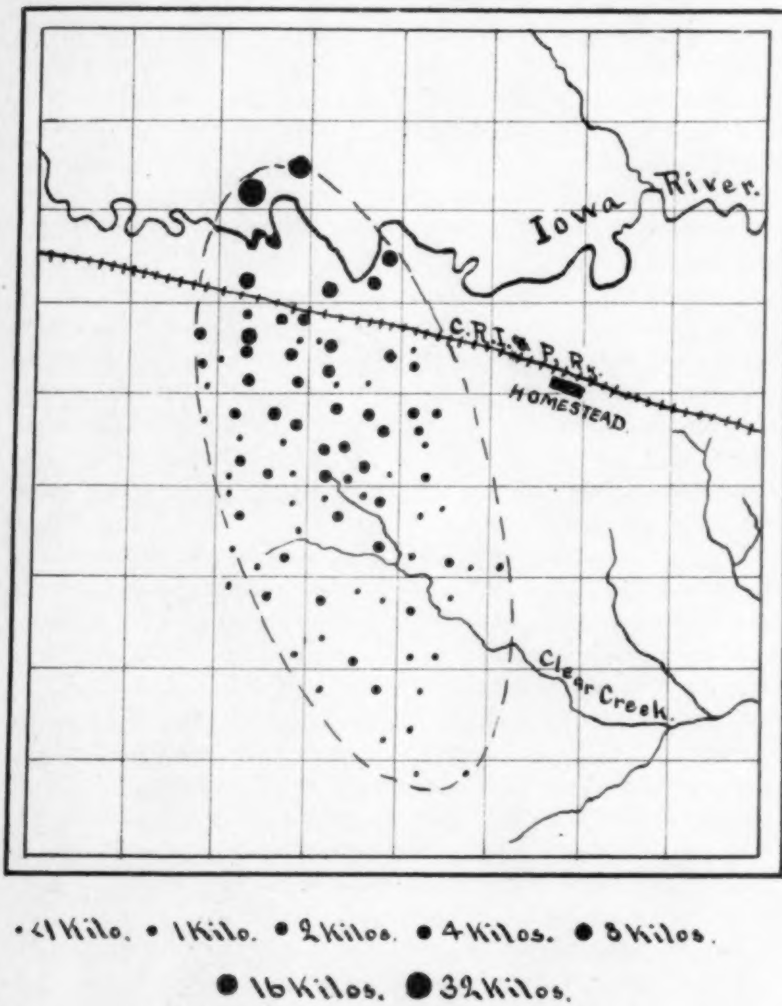

Figure 1. Distribution of Homestead meteorite. The stones fell in an ellipse 7x3 miles in area. The meteor came from the south, and the largest stones were carried farthest.

About 700 pounds of stones were gathered from this meteor. They fell within an elliptical area about 7 miles in length and 3 miles in breadth, the larger ones being at the farther end of the ellipse, as the region is rather thickly inhabited it is somewhat remarkable that no one was hit by one of these stones. If meteorite falls were common occurrences, the danger of being hit by one might be worth considering as a general risk, but they are so rare that no such catastrophe has ever occurred so far as I am aware. The total number of well authenticated instances of meteorite falls in all history is only about three hundred and fifty. This is, however, but a small part of the total number which falls to the earth. The ocean covers three fourths of the surface of the globe and all meteorites falling here are lost. Upon the large uninhabited areas of the earth, too, no record is preserved of meteorites which have fallen. It can be calculated with considerable accuracy that the number of meteorites falling to the earth in a year is about 900, or two to three a day. Yet all that are known number only about 350. Even if we add to these all meteorites found, only about 650 different localities are known. Meteorites therefore are rare objects which must be carefully treasured if we are to learn anything about them.

As regards time of day at which meteorites fall, it is interesting to note that more have been seen to fall in the hours from noon to midnight than in those from midnight to noon. Between noon and midnight 170 falls have been recorded, while between midnight and noon only 87 are known. The majority of meteorites therefore it would seem travel through space with a velocity sufficient to enable them to *overtake* the earth. As to the times of year at which most meteorites fall, it has been found that May and June are the months most favored and October least so. It has been suggested that more are likely to be seen in May and June since more people are out of doors in the summer months, but this argument loses force from the fact that but a small number are seen in July. A noticeable further fact regarding the monthly distribution is that the periods of most abundant meteorite falls are not those of most abundant shooting stars. This appears to indicate that meteorites and shooting stars do not have common origin.

Meteorites may be divided, as regards composition, into three great classes: Stone, iron-stone and iron. These classes pass into each other by every gradation, but their principal characters are

fairly well defined. The stone meteorites are far in excess as regards numbers seen to fall, while the iron meteorites are in excess as regards numbers found. Only nine iron meteorites have been seen to fall, but about 250 have been found. Of stone meteorites 350 have been seen to fall and 40 have been found. It is evident that the reason for the more ready finding of the iron meteorites is that their weight and metallic appearance when struck is likely to attract the attention of an ordinary observer. The stone meteorites on the other hand do not differ notably in appearance from common stones, and hence are likely to be overlooked except in regions where stones do not occur naturally.

In shape and form meteorites exhibit a number of interesting characters. In a large number of cases they may be said to have no definite shape, their forms being irregular and just such as might be produced by breaking a large stone into a number of pieces by a blow of a hammer. This irregular shape is especially wont to characterize the stones of a shower. Other meteorites present more regular forms. Thus one iron meteorite has a flattened cigar shape. It is about three feet in length and weighs 290 pounds. It was found at Babb's Mill, Tennessee. Another meteorite of remarkable form is that known as the ring meteorite, found near Tucson, Arizona. This is an iron meteorite in the form of a complete ring about four feet in diameter and weighing 1,400 pounds. Some have thought this form was due to a rotation of the mass in its descent through the air, by which the air bored a hole through it as an augur bores through wood. It is more probable, however, that such cavities represent a stony or fusible filling which has been pushed or melted out during the descent of the mass. Another form which characterizes several iron meteorites is that of a ramus of the lower jaw of a mammal. This is shown in two iron meteorites, one of which was found in Kokstad, South Africa, and the other in Hex River Mountains, South Africa. The Kokstad meteorite weighs about 80 pounds and the Hex River Mountains about 150 pounds. An explanation given for these jaw-like forms is that they are fragments of what was once a ring like the Tuscon meteorite. Again meteorites may have a shell-like form, indicating that they have scaled off from a larger mass, just as usually happens when a rock is heated and cold water is thrown upon it. Such a form characterizes the Butsura meteorite, which burst into fragments as it fell, but the fragments when put together gave the original form mentioned. The

fragments lay at four points, forming a quadrilateral and nearly a mile apart. The breaking of the meteorite must, therefore, have taken place at a considerable height in the atmosphere and the force of the explosion must have been great to have separated them so widely. Another form exhibited by some meteorites is a drop or pear shape. This is shown by two iron meteorites, one of which weighed about nine pounds and fell at Charlotte, North Carolina, August 1, 1835, while the other was found near Boogaldi, New South Wales. It weighed about four pounds. An interesting feature of the Boogaldi meteorite is a series of concentric rings on the larger end showing that the heavy end was foremost in the fall of the meteorite.

Figure 2. Meteorite with typical conical form, Long Island, Kansas. Weight 1,300 pounds. The form of the pittings and their radiation from the apex as here shown is also typical.

Probably the most beautiful and typical form of meteorites and one of which there are many examples, is a conical one, This is exhibited by both stone and iron meteorites. It is shown by the great iron meteorite weighing twelve tons, found in Mexico, and preserved in the Museum of the School of Mines of the City of Mexico; also in the stone meteorite from Long Island, Kan., preserved in the Field Museum collection and weighing about 1,300 pounds. The form of the cone varies somewhat as to flatness, but is never very steep. This conical form is, without doubt, quite largely the result of the motion of the meteorite through the atmosphere and the heat developed thereby. The part of the meteorite in front feels most strongly the heat and friction and is worn

away on all sides. While this form is quite largely the result of the heat and friction of the air, however, it is not wholly so, since a meteorite possessing a form which tends to be conical will be turned pointed end foremost by atmospheric resistance when it first strikes the atmosphere. Being in that position the heat and friction tend to preserve this form. Evidences of the different effects of this heat and motion are often beautifully shown upon the different sides of the meteorite. Thus the apex and sides of the cone will be found deeply pitted and thinly crusted, while the base of the cone will be found to be comparatively smooth and to have a thick, glazed crust. The pittings also usually radiates from the apex.

The cause of the heat exhibited during the fall of a meteorite, making itself manifest in the bright light given forth, is not any inherent hotness which the meteorite may possess, but the friction of the atmosphere against the mass. The velocity with which the meteorite moves through space is one of about fifteen or twenty miles per second, and this is slowed down by the atmosphere to one of a few hundred feet per second. The motion of the meteorite is thus converted into heat, and if time were given to conduct the heat into the interior the amount of heat would be sufficient to convert the whole mass into vapor. The motion of the meteorite is, however, too rapid to allow conduction to this extent and the effects of the heat are therefore exerted only on the surface of the meteorite. Instead of being intensely hot when they reach the earth, therefore, meteorites are usually scarcely more than milk warm and sometimes even benumbingly cold. This retardation which the atmosphere produces is, further, a means of protection to us from fatal effects, not only of meteorites but of other falling objects. A raindrop falling from a height of 3,000 feet, about that of the average rain cloud, would strike us with a velocity of 400 feet per second were it not for the atmosphere, but as it is its velocity is reduced to about 30 feet per second. So meteorites on reaching the earth have scarcely a hundredth part of the velocity with which they move through space. Besides retarding the velocity of meteorites the atmosphere exercises another beneficial effect in burning up by its friction a great number of stones of the size of shooting stars and larger which would otherwise subject us to an uncomfortable and perhaps deadly hail.

In size, meteorites vary from minute particles to masses of many

tons weight. The largest stone meteorite known is that of Long Island, Kansas, preserved in the Field Museum. This stone, when it came into the atmosphere, doubtless weighed about 1,300 pounds, although as found it was broken into several pieces. Among iron meteorites a number are known weighing several tons. Until within the last few years the largest known was one found in the state of Chihuahua, in Mexico. This was a solid mass of iron weighing about 17 tons. This mass was known for several centuries before being taken to the Mexican Museum, where it is now preserved. Another large Mexican meteorite is that of San Gregorio. This weighs about 12 tons. It has likewise been long known. In 1871, in Western Mexico, in the state of Sinaloa, another large iron meteorite was discovered, but little was known of its exact size and shape until Professor Henry A. Ward of Chicago had the mass uncovered and examined. He found its dimensions to be:—Length, 13 feet; width, 6 feet; and thickness, 5 feet. It has never been weighed, but estimates of its weight make it at least 30 tons. About equal in size to this, or perhaps a trifle larger, and if so the largest known meteorite, is the great mass

Figure 5. The "Peary" meteorite, from Cape York, Greenland. Weight thirty-eight tons. Probably the largest iron meteorite.

usually known as the Peary meteorite. This, as is well known, was first observed by Lieutenant Peary in one of his trips to Greenland, and in 1897 he made a special trip to procure it. This mass has a roughly spherical shape and weighs about 38 tons, On account of its shape, probably, it was known by the Esquimaux as the "tent." Two smaller masses near it were known respectively as the "woman" and the "dog." The dimensions of the large mass are 11 x 7 x 6 feet. It is preserved in the American Museum of Natural History in New York City.

One of the largest iron meteorites so far known was discovered near Willamette, Oregon, in 1902. In dimensions it nearly equals the large Peary mass, the dimensions being 10 x 7 x 5 feet. As it originally fell it was perhaps the largest iron meteorite yet known, but it has been greatly channeled and furrowed by the action of the atmosphere since its fall, so that its original weight has been greatly reduced. It probably, however, weighs at least ten tons. It has in the main a conical shape and was found pointed end down, showing that it fell in that position.

As regards the three great groups of stone, iron-stone and iron meteorites, the stone meteorites resemble in composition most nearly some basic volcanic rocks of the earth. Silica, magnesia and iron oxide are the chief components, with a little iron, nickel, potash and soda. The form in which these components appear as minerals is chiefly as chrysolite, bronzite, feldspar and metallic grains of iron and nickel. The color of stone meteorites is, as a rule, light to dark gray, though they sometimes become brown through oxidation. They are usually covered more or less with a crust resulting from the fusion of the surface and this is generally black in color. Most distinctive of all are the metallic grains scattered through the meteorite, a feature which terrestrial rocks do not exhibit. Another feature of the intimate structure of many stone meteorites never duplicated in terrestrial rocks is a constitution of little mineral balls. These balls, called chondri, vary in size from a dust-like minuteness to that of a pea. They do not exhibit a concentric and amorphous structure as the spherules of terrestrial rocks usually do, but are radiated and well crystallized. They usually consist of a single mineral and one common to the meteorite, such as chrysolite or bronzite. Sometimes the chondri make up practically the whole mass of the meteorite, or they may occur only here and there, the rest of the stone in such case often consisting of splinters and debris of

Figure 4. Typical meteorite chondrus as seen in section under the microscope. Magnified fifty diameters.

chondri. The origin of the chondri is not understood. Some have thought that they represent a peculiar form in which the minerals of the meteorite have crystallized, while others regard them as having existed as individual bits of matter which by trituration acquired a spherical form and were later aggregated together. Stone meteorites containing chondri make up by far the larger part of stone meteorites known, but there are some stone meteorites which exhibit no chondri whatever. Most of these have a crystalline structure closely resembling that of terrestrial volcanic rocks.

The iron-stone meteorites are distinguished from the stone meteorites by greater content of metal. This metal may be simply in the form of larger grains scattered through the stony material, or may form the framework of the mass and the stony minerals be held in it as in the pores of a sponge. In meteorites

of the latter character the siliceous mineral is generally chrysolite.

The iron meteorites contain no silicates, only metal, with sulphides, phosphides and carbides of nickel and iron. The metal is chiefly iron, with which is associated from 5 per cent to 20 per cent of nickel, 1 per cent to 0.5 per cent of cobalt and .02 per cent to .01 per cent of copper. Phosphorus, sulphur and carbon are almost always present in combined form. With iron and nickel these form the minerals troilite, schreibersite and cohenite, which almost never occur in terrestrial rocks. The most interesting and peculiar feature of iron meteorites and one which distinguishes them from all terrestrial bodies, is the figures which they afford upon etching. If a smoothed surface of an iron meteorite be treated with acid, bromine water or other etching agent, there soon appear upon it regular figures. These figures have the appearance of a network of fine lines crossing each other at various angles. They run regularly through the mass of the meteorite except where interrupted by inclusions of other minerals. The figures are known as Widmanstatten figures in honor of Alois von Widmanstatten of Vienna, who first discovered them in 1808. They characterize the great majority of iron meteorites, though not all. When one of the surfaces showing figures is

Figure 5. Typical etching or Widmanstatten figures obtained by treating a smooth surface of an iron meteorite with acid.

magnified further detail are brought out. What appeared to be mere lines as seen with the naked eye prove on magnification to be broad bands of iron-gray color bordered on each side by narrower bands of nickel-white color. The former are called kamacite, the latter taenite. Analyses of the broad and narrow bands show that the narrow bands contain more nickel than the broad ones. They are therefore less attacked by the etching fluid and stand out in relief. There is also a third ingredient called plessite which fills the intervening spaces produced by the crossing of these bands and which is found to be intermediate in composition between the two other alloys. The structure indicated by these bands is crystalline, and the crystal form which the arrangement of the bands follows is that of the octahedron. Some iron meteorites, however, follow the planes of a cube rather than those of an octahedron and give figures of a different character.

Comparing the structures of the iron meteorites with those of the stone meteorites, we find that the iron meteorites are completely crystallized, the stone meteorites incompletely crystallized. If this crystallization has been acquired as the result of cooling from a molten magma, as seems probable, then the structure indicates that the stone meteorites cooled rapidly, the iron meteorites slowly. If the two kinds of meteorites were ever combined in one mass, as the unity of their constitution seems to indicate, such differences in rate of cooling would be likely to be produced if the iron were at the center of the mass, the stony on its surface. There are some reasons for believing that the earth may have a constitution of this character. The density of the earth as a whole is about twice as great as that of the rocks which form its crust. Its interior must, therefore, be more dense than its crust, either because of different constitution, or because of pressure. If the density is due to difference of constitution, it is quite likely that iron is the substance which produces it. In a list of the elements of the earth in the order of the abundance as we know them, oxygen takes first place, then comes silicon, aluminum and iron. In meteorites, however, iron takes first place, then comes oxygen, silicon and magnesium, while aluminum is present but in small quantity. The reason for these differences is probably that we are comparing, of necessity, only the constitution of the *crust* of the earth with that of meteorites. If we could compare the substance of the earth as a whole with that of meteorites, it is

quite likely that they would be very similar. We have some reasons, therefore, for thinking that in meteorites we see the complete constitution of some sort of larger cosmic body. If meteorites do represent such a larger body what was probably its nature? Was it a moon, or a planet, or a body of some other character? The view that meteorites may have come to us from the volcanoes of the moon was quite widely held some years ago. The great craters of our satellite, some of them more than 100 miles in diameter, may indicate that great explosions may have occurred there at times. But astronomers have shown that if matter was shot from the moon, the chances of its ever reaching the earth would be too few to give us the great number of meteorites that we have. Further, the explosive force necessary to throw them out of the range of the moon's attraction would be greater than any that is likely to have existed. The same objections prevent our regarding meteorites as matter which has been shot from the volcanoes of the earth. Our big guns, 50 feet long, which throw a projectile weighing about a ton a distance of 21 miles, only give to the projectile a velocity of one half of one mile per second. In order to throw an object off the earth, however, a velocity must be given about 14 times as great as this. Neither man nor earth, so far as we know, has ever produced such a projective velocity. Another difficulty which we would encounter in undertaking to trace the origin of meteorites to our earth would be that no terrestrial volcanoes, so far as we know, have ever ejected matter of a composition like that of the majority of

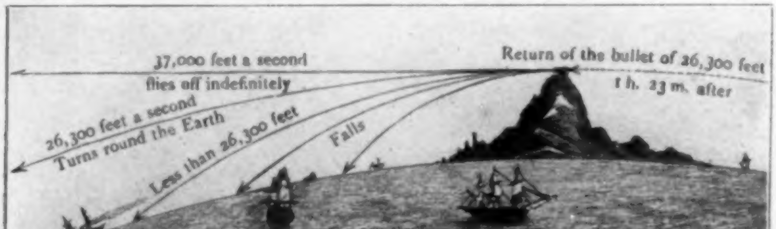

Figure 6. Diagram showing paths of projectiles of different velocities.

meteorites. If neither the earth nor the moon produce these bodies, it is not likely that any of the bodies of our solar system could have done so, neither any of the fixed stars. Is there, then, any class of heavenly bodies to which we may ascribe a possible

origin of meteorites? Our present knowledge seems to confine us to one if any, and to that by no means certainly. This one class of bodies is the comets. These are erratic celestial wanderers which have come into tenestrial view for a few hours or months, then disappear, perhaps to return in a few years, perhaps never to return. The size of these bodies is often remarkable. Such an one was Donati's comet, of which the head alone was estimated to have been 250,000 miles in diameter and its tail ten millions of miles in length. As it neared the sun great streamers shot out from its head and lay in filmy lines across the sky, often changing position and form. In other comets divisions and coalescences of the tail have been observed. Thus Borelly's comet when first seen had a simple tail. Two days later this subdivided into two and in two days more each of these divisions split in two. On the following day they coalesced again. Around the heads of comets are usually to be seen also luminous envelopes like the coats of an onion, which peel off and disappear. All these observations show that comets tend to break up and become dissipated under the disintegrating force, probably, of the sun's gravitation. One comet indeed, that called Biela's, was seen to break in two and has never been seen since, although the shooting star shower called the Andromedes has the same orbit and probably represents the disintegrated comet. Between other comets and shooting stars similar relations have been discovered. Thus the August meteors have the same orbit as Tuttle's comet, and the Leonids as Tempel's. The shooting stars thus seem to be the debris of comets. If meteorites are only large shooting stars, then there would seem to be good reason for regarding them likewise as cometary fragments. But meteors exceed shooting stars considerably in mass and are far more isolated in origin. They have higher velocities and do not group in times of fall with shooting stars. Moreover our knowledge of the mass and constitution of comets is not sufficient to warrant our asserting that they could produce meteorites. No comet has ever been observed possessing sufficient mass to cause a perturbation of movement in a larger heavenly body by its passage near it. Further, it is not unlikely that the constitution of comets is gaseous rather than solid. We are thus unable as yet to assert positively that meteorites are the children of comets. We can only say definitely

in regard to them that they are solid fragments encountered in space by the earth and drawn in by the force of its superior attraction. When thus secured they give us the only tangible link which connects our earth with the vast areas of the universe beyond it.

SCENE IN GRAND CANYON—SANTA FE RAILROAD

WHY TEACHERS UNIVERSALLY FAVOR THE METRIC SYSTEM.*

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It is a fact so well nigh without exception that it may be called universal that teachers and college professors who know the Metric System even superficially are enthusiastic believers in it. That is to say those people who are most broadly educated and who come in contact most often with both the customary and metric measures, are the greatest believers in the universal adoption and use of the Metric System. What class of persons as a unit is best qualified to judge of the merits of a question, those who constantly are seeing both sides of the question, and who by reason of education are qualified to discriminate, or the other class?

The question is raised here only because it is often said by manufacturers and business men that college professors and teachers are mere theorists with no practical knowledge. This has been the burden of criticism of certain uneducated men who have opposed the Metric System. It is indeed more or less true of purely literary men, whose knowledge of meter is confined to Greek hexameter; but take the case of scientifically educated college professors and teachers in technological schools. Who is the expert to whom geological questions are referred? Is it not to the college professor? Who is the man to decide the chemical analyses of ores, of poisons, of foods? Is it not the college professor or at least the man trained as such? The court of last appeal in all knotty scientific and technological questions is the expert, who in nine cases out of ten is a professor. Most manufacturing concerns of any note have consulting chemists to whom are referred questions that the manufacturer himself or his local chemist cannot answer. These are college professors. The same is true in electrical science; in fact, in all sciences. Yet it is habitually flaunted in their faces that they are lege professors. This common objection then has no foundation in fact, and never had any. College men and teachers are the best qualified to judge of merit in their specialty.

When we find an almost universal consensus of opinion in

*From the New York Herald (in part).

favor of the Metric System by men and women that have taught and studied the subject of weights and measures, as college men and as teachers have, ought not that opinion to have more weight than some people are disposed to give it? It is here contended not only that such persons are qualified to give judgment, but that they are honest in their convictions, and that this judgment is wholly uninfluenced by questions of cost of change from a poorer to a better instrument of measure. Among teachers I have scarcely ever found an opponent to the adoption and use of the Metric System, and all who have studied the question I believe endorse it, a majority with much enthusiasm.

One great item which is generally overlooked in discussing the subject from a teachers' standpoint is that arithmetic would be taught far better than it is in our schools today if we used the Metric System. The time saving element of the problem is not after all the chief, though it is a great one. From all the schools in this country—grammar, high and technical as well as colleges—comes the complaint that students are poorly prepared in arithmetic. This was the one burden of the New England Association of Mathematical Teachers at its last meeting. College professors and those from technological schools say their students cannot divide when dealing with decimals. It is my experience that high school students, who have all their arithmetic in the grammar schools, almost invariably, in dividing with decimals, introduce some character to change the place of the decimal point, because otherwise they do not know where to place the point in the quotient. A common character is the caret, which they have been taught to insert to mark the place of the changed decimal point. It is scarcely enough to say that it is the fault of the teaching. Partly it is due to method, partly to lack of time. The fact is decimals are put into the background, whereas they should be foremost in teaching fractions, though few arithmetics and very few teachers make them so, because of our antiquated system of weights, measures and fractions. Introduce the Metric System in general use, as it is in France and Germany, and the teaching of decimals would be of paramount importance, and there would then be little complaint among the higher schools and colleges that pupils cannot cipher correctly in simple decimals. It is today the universal cry.

Among scores of estimates I have seen of the amount of time saved in a student's life were the Metric System in exclusive use

the majority of statements make it at least a year. But very few of the pupils know half the customary weights and measures or can work expeditiously and accurately with them. It is time wasted to learn such an unnatural system of weights and measures as ours, especially when it is only half learned. I have myself taught classes who never before knew aught of the Metric System, so that the members could, in two hours' time, solve ordinary problems. Why is it that the German boy, when he enters the university is two years ahead of our boys of the same age who enter college, as we have ample testimony? A part of it is most certainly due to the enormous waste of time and energy in working problems and learning tables of antiquated measure, which leave on his mind the impression that nothing in mathematics is simple. Yet the Metric System in all its bearings is so complete and simple as well as so scientific that any man who fails to see its superiority over our unscientific measures must have a distorted mind. Before me is a series of French arithmetics. In these the treatment of decimals follows at once that of the whole number, notation and numeration of the former following that of the latter, likewise the addition of the two, then subtraction, multiplication and division. Not until each of these topics has received so complete a treatment that the pupil can work in decimals as easily as in entire numbers, is the subject of common fractions introduced. This is as it should be and is what the introduction of the Metric System would mean to the schools in this country. In not a few places the Metric System is still taught in the grammar schools of the United States. In Boston and other cities, owing to the agitation and influence of Melvil Dewey and the American Metric Bureau, the system was a required subject of the grammar schools from 1878 to 1887, when, through the influence of Francis A. Walker, then President of Massachusetts Institute of Technology, it was relegated to the high school, where it has since been taught only with rare exceptions to classes in physics and chemistry. Last year the Eastern Physics Association undertook to ascertain the extent of Metric System teaching in New England, with the result that out of 155 replies 86 schools taught it to some extent. Even these seemed to be largely relics of the agitation of 1876 above referred to where school committees had not revised the course to exclude such teaching. It is a great pity that so many persons, graduates of our grammar and even high schools, know really nothing of

such a simple and widely used instrument of measurement and computation. Among so-called well informed people the questions are common ones: What is the Metric System? Is it used in any country? In the schools of England the teaching of it is universal, and legally compulsory. I believe that every teacher of mathematics who is at all familiar with the subject would, if he or she had the opportunity, endorse most heartily a movement to introduce the Metric System and make its teaching obligatory. Were it in use, there would result to both teacher and pupil great saving of time, greater economy of mental energy, and greatest of all the recognition of scientific simplicity and completeness. It is a burning disgrace to our system of education that a few opponents, because of the paltry cost in machine shops and textile works and a few months perchance of confusion, should hold up that system which the enlightened judgment of the educated world has pronounced infinitely superior to the brain-wearing, time-killing, energy-annihilating system of measurements that came into use in the middle ages and earlier. Let us bring to light the opinions of those best qualified to judge.

If every educational association of whatever sort, and every teacher throughout this broad land could have a voice on this question, the chorus would be overwhelmingly in favor of this reform. If every believer would write his congressman and his senator urging action, something might come out of the present apathy. We who believe in a better measure hope that every man will use his efforts to further a cause for which future generations of children and teachers, business men and manufacturers will rise up and thank him.

FERRY STEAMER "OAKLAND," SAN FRANCISCO BAY

SOME DIRECTIONS FOR ELEMENTARY LABORATORY WORK IN PHYSIOLOGY AND HYGIENE.

By Louis Murbach.

[CONTINUED FROM THE APRIL NUMBER.]

TASTE AND SMELL.

To Learn What Smell Has to do With "Tasting" Things.

Experiment 1. Small pieces of apple or potato and onion are cut on a fresh piece of paper. The nose is then closed by pinching with thumb and forefinger as near the bone as possible, so as to prevent breathing through the nose. In fact the student will succeed better if he practices breathing through the mouth for a little time. Without looking one of the pieces is then laid on the tongue with one hand, still holding the nose closely with the other. Taste the piece, being sure not to breathe through the nose. Now open the nose and again taste the piece; which way could you tell the kind of piece taken better, when tasting alone or when smelling in addition to tasting? In case you did not get the onion the first time, try it next in the same careful way. What is the result? What is the conclusion? Do we *taste* the characteristic of onion? How does the piece of onion taste? How does it smell?*

Experiment 2. To learn what condition of a substance is necessary in order to taste it: The surface of the tongue is wiped dry and some dry sugar sprinkled on it. The finger is now dipped in dissolved sugar and is placed on the tongue, or the dry sugar on the tongue may be allowed to become moist by the saliva. What is the result with dry sugar on dry tongue; what with dissolved sugar? What conclusion as to condition necessary for taste?

HEARING.

A wire is stretched tightly between two fixed points. The wire is pulled to one side and released. If you will close your eyes when it is pulled to one side can you tell when it is released? How? Unless you already know the name of the to and fro motion of such a cord learn to call it vibration. This illustrates how all kinds of sound are produced, i. e., caused. Do the vi-

*At home the student may try other things such as ground coffee, or cinnamon, turnip cheese, etc., and report and write up in note book.

brations of the string reach the ear? What does the vibrating string strike that does touch the ear? This holds true for all sound reaching the ear normally. By what medium, then, does sound reach the ear?* If there is time this may be proved in the following way: A clock with an alarm is placed under an air-tight bell-jar of an air-pump and the air drawn out of the bell-jar. The alarm-clock has been set so as to go off soon after most of the air is out of the bell-jar. Watch the hammer of the clock striking the bell. Do you hear it? Why? Now the air is admitted. What difference does it make. What does this experiment prove?†

SEEING.

Introductory.

By what light do we see the sun or a flame? Give an example of any other object we see in the same way. These are called self-luminous bodies. By what light do we see non-luminous bodies such as a table or the moon? Give other examples of non-luminous bodies. In what two ways, then, do we ordinarily see objects? The first is called direct light, the second reflected light. What kind of bodies are, after all, the source of light that is reflected from anything?

Experiment 1. To learn in what kind of lines light travels: A beam of light from a window or the lantern is made visible by some light powder or smoke from some source such as Japanese incense or the beam is passed through some colored liquid. Judging from these observations in what kind of lines would you say light travels?

Note.—This holds true as long as light travels in media (substances) of the same density. In denser media light travels slower than in less dense media; e. g., in a gas (the air) light travels much faster than in water or glass. Still light travels in straight lines as long as it passes straight (at right angles) from one of these media to the other. It is because light normally always passes in straight lines that we think we see things in the direction from which light comes to the eyes. That objects are not always where they seem to be will be seen in Experiment 2.

Experiment 2. To learn how light is affected when passing slantwise from one medium into another of different density:

* Another way of conducting sound to the ears may be illustrated by holding a watch or any sounding body against the teeth while the ears are externally closed. How is the sound now conducted to the ears? Some kinds of ear trumpets are made to be used on this principle.

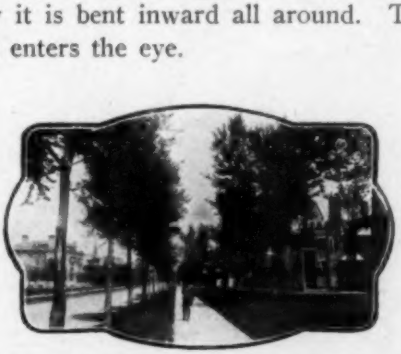
†A bell in a flask from which most of the air is removed by steam has been tried.

A ruler is placed slantwise in a tall tumbler (or other glass vessel) and the eye is so placed at the upper end of the ruler, in line with the surface, that the lower end can be plainly seen but none of the intervening marks can be. An outline drawing is made of the ruler, the glass and the eye in this position, as seen from the side. Again sighting over the ruler as before, water is poured into the glass until nearly full. How does this change the appearance of the ruler from the edge of the water down to the end? This appearance is represented by a dotted line drawn from the point where the ruler enters the water (a) to where the end appears to be (b). Being sure that your eye is in line with the surface of the ruler again look to see if the marks on the ruler are visible more plainly on one part than another. Where do they become the plainest?

Note.—It is assumed all along that the student understands that he sees the end of the ruler by reflected light.

When water is poured into the glass in what direction does the light enter the eye? Represent this by a dotted line drawn from the point (b) where the end of the ruler appears to be, to the eye. Where this line crosses the water's surface the letter c may be placed for reference. Does the light really come from b that enters the eye from c? A solid line is now drawn from the real end of the ruler c and from c to the eye. What does this line represent? Why does the ruler appear bent at the surface of the water? How is light affected in passing slantwise from water into the air?

The light is said to be refracted and the phenomenon is known as refraction. In passing through lenses light is affected in the same way, only it is bent inward all around. This is the case also when light enters the eye.



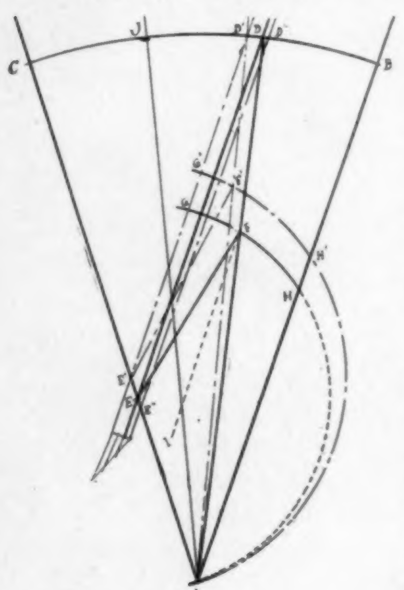
STREET SCENE, DENVER, COLORADO

TO TRISECT AN ACUTE ANGLE.

By C. S. Floyd,
High School Pupil, St. Joseph, Mo.

CONSTRUCTION.

Take any angle (C A B) less than a right angle, and on the side C A take E′ A less than one-half of the side C A and so that the perpendicular distance from the point E′ to the line A B is greater than one-third of the arc C B. Now through the point E′ on the side C A draw a line parallel to the side A B and intersecting the arc CB at the point D′. Draw a straight line from the vertex A through the point D′. Then with the point E′ as a center, with a radius equal to E′A draw an arc from the vertex A intersecting the lines AB and AD′ at H′ and F′, respectively. Now with a radius equal to one-half the line E′F′ + F′D′, with the vertex A as a center, determine the point E″ on the side CA; then through the point E″ draw a line parallel to the line E′D′ and intersecting the arc CB at the point D″. Then draw a line parallel to the line E″D″, and between the lines E′D′ and E″D″, cutting the side CA at the point E, and the arc CB at the point D. The space between the lines ED and E″D″ being equal to one-third of the space between the lines E′D′ and E″D″. Now draw a straight line from the vertex A through the point D; then of the angle (DAB) thus formed is equal to one-third of the angle CAB, and the angle CAD is equal to two-thirds of the angle CAB. Now draw the line AJ bisecting the angle CAD; then the angles CAJ, JAD, and DAB, each is equal to one-third of the angle CAB.



PROOF.

With the point E as a center, with a radius equal to the line EA, draw an arc from the vertex A cutting the line AB at H, and the line AD at the point F, so that the line FD equals the line EF. And draw a line (IF) parallel to the line ED and through the point F.

The $\angle$DAB = $\angle$ADE. (If two parallel lines be cut by a third straight line the alternate interior angles are equal.)

And $\angle$FED = $\angle$ADE. (Since the angles at the base of an isosceles triangle are equal.)

Then $\angle$FED = $\angle$DAB. (By the axiom things equal to the same thing are equal to each other.)

And $\angle$IFE = $\angle$FED. (If two parallel lines be cut by a third straight line the alternate interior angles are equal.

Then also $\angle$IFE = $\angle$DAB. (By the axiom that things equal to the same thing are equal to each other.)

But $\angle$EFA = $\angle$ADE + $\angle$FED. (For if one side of a triangle be produced, the exterior angle thus formed equals the sum of the two opposite interior angles.)

And as $\angle$IFE is one part of the $\angle$EFA and is equal to $\angle$FED which is equal to ½ $\angle$EFA.

Then $\angle$IFE = ½ $\angle$AFE. (By the axiom that things equal to the same thing are equal to each other.)

And as $\angle$IFE + $\angle$IFA = $\angle$EFA

Then also $\angle$IFA = ½ $\angle$EFA

Then $\angle$IFE = $\angle$IFA. (By the above axiom.)

And the line IF bisects the $\angle$EFA.

And $\angle$IFA = $\angle$DAB. (By the above axiom.)

The $\angle$EFA = $\angle$CAD. (As the angles at the base of an isosceles triangle are equal.)

And as the line AJ bisects the angle CAD (By construction), the $\angle$JAD = $\angle$IFA, and $\angle$CAJ = $\angle$EFI.

Then $\angle$JAD = $\angle$DAB and $\angle$CAJ = $\angle$DAB. (By the axiom that things equal to the same thing are equal to each other.)

As $\angle$CAJ = $\angle$JAD = $\angle$DAB

And $\angle$CAJ + $\angle$JAD + $\angle$DAB = $\angle$CAB.

$\therefore$ The triangle is trisected.

THE TEACHING OF PHYSICS.

By H. N. Chute,

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[CONTINUED FROM THE APRIL NUMBER.]

To-day the pendulum is swinging the wrong way and it may be some time before it begins to return. In the meantime, it will be necessary for the physics instructor to spend much time in teaching arithmetic, not to mention penmanship, English, and housekeeping; occasionally he may find an opportunity to do a little work in physics.

I believe that most boys and girls, too, would enjoy the study of physics were it not for such difficulties as I have described, all of which grow out of their inadequate preparation for such a study. They are charmed by its novelties and enchanted by the beauties revealed. But before they have gone far into the subject, they come to a gate, with written above it in the language of Plato of old:—"Let none but geometricians enter here." Should they venture to pass within its portals, they find themselves in an atmosphere of mathematics, the forms of expression, many of the ideas are the children of mathematics. It was this fact that prompted Kepler to exclaim that, "the laws of Nature are but the mathematical thoughts of God."

I presume that the question now uppermost in mind is, "What can the teacher of physics do in the face of such difficulties?" Perhaps not very much, but I believe that he can help matters a little, notwithstanding the fact that habits of thought and methods of work are largely formed on the part of the student and in many cases ossified before he reaches physics.

One of the most general weaknesses to be found in pupils is in their almost utter helplessness in the face of a new problem. Here is a problem differing from the last one solved; it may be in mere phraseology, and he is hors de combat. Never with him does the thing asked have any connection in his thought with the solution. Every problem hitherto solved has been an effort of memory or a game of chance. He added, he divided, he subtracted, and looked for the answer. If obtained, all was well; if not, he tried another combination. Problem solving to him is puzzle solving, it is a jugglery with figures; it is a trying of all

the combinations, a method of exhaustions. If you doubt this description, try the following on your class and watch the results:—A force of ten dynes acts on a mass of nine grammes and moves it eight centimetres. How much work is done? If I am not greatly mistaken the solution given will involve every quantity mentioned in the problem, regardless of what was called for.

We all admit that a change is very desirable. But how may it be brought about? You may establish mathematical laboratories, with blocks, rulers, and protractors galore; it matters not what concrete methods you adopt, problem solving will ever be the bug-bear of the school-boy until you make it more than has yet been done a question of sentence analysis, a study into the meaning of the words used. My contention is that the solution of every problem is to be found in the problem itself; that in asking for a certain thing to be found, a correct interpretation of the thing asked for, tells how to get it. Considerable experience in teaching both mathematics and physics have convinced me that no true progress can be made along any other road.

I have an impression that students are rarely taught in accordance with this precept; and my observation is, furthermore, that problem work especially in algebra, is very largely ignored and instead the pupil is drilled from day to day on cut and dried equations and the reduction of complex expressions, and has little or no opportunity given him to learn how equations are written out of problems. And so the teacher has a severe task before him of training his pupils in the art of problem solving, in the method of attack. You will find that many will be attracted to your work by this novelty and you will save to your classes all that are probably worth saving.

Another perplexing problem to the instructor is the management of the recitation. Shall it be topical or catechetical? Why not both, neither exclusively? It would seem wise at times, quite frequently in fact, to have the student take up a topic and reproduce the thought or discussion, the merit of the performance varying inversely as the amount of prompting required. He should also be able, and often be required, to answer questions bearing on any part or feature of the subject under consideration. The answer, it should be insisted, should fully meet the question asked, be it a definition or the underlying principle in any experiment, discussion or process, all to be presented in good English

form, for this after all, is the most satisfactory evidence of acquired power.

And why have the questioning all on one side? The student that asks no questions is usually one that does no thinking. Many times some of the most helpful points are brought to the front through some question asked by a thoughtful student.

In these days we hear a great deal about the Laboratory Method. Sometimes I think that the teaching world has gone daft on this subject, for have they not tried to apply this method to the teaching of every known subject from cube root to Caesar. There are those who maintain that in science instruction this method should be used exclusively, that the pupil should "read Nature only in the light of experiment," a very catchy injunction, to be placed by the side of that other much abused pedagogical saying "Learn to do by doing." Our heuristic friends tell us that all information should reach the student through experiments performed by himself, that on entering upon his work he should be practically in the same state as regards scientific knowledge as the original performers of the experiment. "These original discoverers—the Newtons, Daltons, Cavendishes, and Blacks—says a writer in the School World, were ranked amongst the foremost intellects of their age, and this is a position that we can hardly expect the average school boy to occupy. The result is that the pupil is considerably in the dark as to the argument of his experiment, and in the majority of cases remains so. The heuristic method makes too little allowance for the naturally illogical nature of the average boy." Many of the fundamental facts of science, to develop experimentally, require the highest type of mechanical skill, most accurately constructed apparatus, and observational powers trained to the greatest acuteness. Then why have a laboratory associated with the teaching of physics? What is its mission? Certainly not discovery, neither is it verification, for the establishment of principles and laws is clearly beyond the skill of the novice, when men of genius ofttimes labor hard and long to bring things to pass. Prof. Woodhull points out one of its uses in that "the student gets a realizing sense of things by coming in contact with them." And then the training it gives is not surpassed by that in any other line of work. It offers unparallelled opportunities to cultivate the observational powers. How few people use their eyes as they go through this world and still fewer see things just as they are. Ask your class

to tell you which stroke of the letter V is shaded, the direction of the inclined bar in N, and which way S curves, and it may surprise you to find what a large number are wrong. Appoint two students, without any laboratory training, to take independently the reading of a barometer at a given time and the difference in the reports is ofttimes considerable. Furnish a boy with dividers and scale and set him the task of measuring the length of a straight line that you have drawn on a sheet of paper, and it is wonderful how that line seemingly expanded and contracted during the progress of the work, and all because he had not the ability to see when one point was exactly on another, neither did he possess any ideas as to how he might assure himself when he had so placed them. Did you ever have a girl try to light the vertical rod of the iron ring-stand for a Bunsen burner, nearly twisting off the screw that clamped the ring in her frantic endeavors to turn on the gas? I have, more than once. Did you ever know a college president whose knowledge of Greek, Logic and Theology was unquestioned and yet he could not light the kerosene lamp on his study table. I knew one, and as you might expect he was no advocate of laboratory methods in education, and opposed to the bitter end the able teacher of physics in that college who was trying to inaugurate modern methods in his work and finally ousted him from his position. This man had seen a lamp lighted thousands of times, and yet there was a sense in which he had never seen it lighted. The ability to see things correctly is not a gift, it is an acquirement obtained through proper training, and it is in this direction that the physical laboratory renders most valuable service to those that work therein, The training to exactness and carefulness is another of its most important fruits. "All exact knowledge, says Maxwell, is founded on the comparison of one quantity with another." Knowledge that is not exact has but little value and frequently is a detriment to the possessor. Let a student undertake to find the value of "g," and he soon discovers that he must measure the length of his pendulum within a millimetre to secure a result of any merit. And so all through the properly managed laboratory course, he has impressed upon him at every turn that if he cannot see accurately, manipulate carefully, and adjust with precision, there is nothing in store for him but failure, as there is "no apparatus of such cunning that it will not permit itself to be set wrong or to be read wrong, and of such vigor of constitution

that it will not mind being knocked off the table occasionally." He meets here with the highest type of manual training. He finds as he enters upon an experiment there is something for him to do that demands his closest attention. Here is a careful adjustment of the position of a scale and success hangs upon a hair's breadth deviation; a pressure to be measured by the sense of touch and failure is the penalty if his fingers give him no sense of magnitude; a group of apparatus to be formed and joined so that all parts work in perfect concert, if anything comes of his manipulations. He must adjust to hundredths of a millimetre, he must see to the tenth of a degree, he must weigh to the thousandths of a gramme, he must maintain a constant pressure on the contact key or his galvanometer needle will never rest; he must assemble the apparatus so that every part is easily accessible and every necessary adjustment is possible without upsetting everything in sight. "The habit of intelligent care, has been declared by some one, to be one of the most important objects to be attained in an education." Dr. J. O. Reed very forcibly expressed my point, when he said:—"The student who has learned to handle a spherometer or a vernier caliper properly, who can measure the focal length of a lens without dropping it upon the floor, who can adjust and operate a balance or a spectroscope without tearing either of them to pieces, in short, who can take up and use any piece of apparatus in the laboratory intelligently, and when done replace it where it belongs in as good condition as he found it, has made an acquisition for life."

In the system and order demanded in the laboratory we have a type of training furnished as thoroughly no where else. It is a place for work, neat and orderly work. One of its regulations should be "a place for everything and everything in its place." That teacher who permits a student to keep his table looking as if a cyclone had just swept across it, or closes his work for the day leaving everything in a turmoil, has certainly missed his calling. His place is in the junk-shop, where dirt and chaos may reign supreme, and no one be injured thereby.

I have already referred to the student's difficulty with language, his inability to arrive at the full meaning of a sentence. It is in the laboratory that he will find by sad experience how serious a matter this is. Directions not followed frequently bring disaster, and the bill for broken apparatus startles him. How few there are who are able to follow out to the letter a set of printed in-

structions, I care not what the subject, and yet how often it is true that success can come solely by being able to do this.

It is in the laboratory the pupil learns the nature of experimental evidence. In the class-room as well as from the text-book he learns that a body submerged in water is buoyed up by a force equal to the weight of the water displaced. In the laboratory he soon finds out that exercising all the care of which he is capable he is unable to realize exactly this fact; but he notices that his measurements are marred by errors and that by increased care, which he comes to know how to exercise through experience gained by repetition, he approaches nearer and nearer a realization of the principle as stated, leading him to believe that if he could observe with still greater accuracy, and had at his command apparatus entirely divested of mechanical depravity, he could obtain results in perfect harmony with the principle of Archimedes.

The independence of thought and the consciousness of power that the laboratory begets are results of incalculable value. Mere head knowledge, or learning, does a man but little good. It is the habit of mind, the training in method and the cultivation of all his powers that determine his character and fix his worth. I sometimes doubt whether the primary aim of laboratory work in physics in our schools should be "scientific habits of thought about physical phenomena," so much as systematic habits of bringing things to pass. That physics cannot be taught without a laboratory is a very doubtful proposition, that it can be taught as well and with as much benefit to the pupil without it is certainly not true. In my judgment, the most effective teaching can be done by a judicious combination of methods. The text-book is needed to place before the student concise and accurate statements of the important facts and principles and furnish him language in which to express his ideas; the lecture and demonstration are needed to explain and illustrates laws which students cannot do for themselves from lack of time, or skill, or both; the laboratory is essential to make knowledge real and vivid in the student's mind and acquaint him with the method by which physics grows; and the recitation or quiz is indispensable for fixing facts, for ascertaining with what clearness the principles are understood and as a prod to those disposed to lag or shirk.

The proper apportioning of time between these different phases of the work is a difficult matter to determine, and one in which

there is danger of going to extremes. Some place too much stress on the laboratory and too little on the quiz, others go to the opposite extreme, and the laboratory is one only in name, being an injury to the pupil in many ways. If there was unlimited time for physics there would be less difficulty in the matter. We must remember that the pupil has other subjects that demand a fair share of his time. It might be of interest to some to know the practice of the school with which I stand connected. The week's work in physics comprises four class periods, each of one hour in length, one laboratory period of three hours' length and a laboratory report. Of the class periods, one is either a review of the class work, a quiz on the laboratory work, or a combined quiz on the two. A few years ago there were rumors among the teachers in our school that physics was demanding more time than was accorded to other subjects. The superintendent made a thorough investigation of the matter at the time and found that the charge was not based on fact, that there were at least five subjects paralleling physics in the various courses that were given more time by the pupil than was accorded to physics.

The length of the recitation period is another important question, and I am constrained to say that, in many schools, in my opinion, it is entirely too short. Experiments are great time consumers, many of them cannot be hastened. It is very necessary that every feature of an experiment be fully emphasized and the principles made clear, and whether clear or not determined by a few well directed questions. Experiments should be enforced by live illustrations brought in from the world of activity, to the end that the pupil may see wherein these principles have useful applications.

And finally, there is as much in the man as in the method or arrangement of work. "Physics, as Dr. Hall has said, is at the best, hard for most minds, young or old; and if the teacher is blessed with the gift, or can by pains acquire the power, of presenting his subject in an attractive way, of making his teaching artistic in form as well as sound in substance, he will win not only the respect of his pupils, but what is perhaps to both sides more stimulating, their admiration."

SOME PRACTICAL APPLICATIONS OF ELEMENTARY GEOMETRY.

By Mabel Sykes,
South Chicago High School.

The new psychology says that the mind is not a collection of faculties and that any attempt to train these faculties separately must always be essentially inadequate. The mind is a whole and as a whole must be trained to effective doing through the solution of practical problems. Two deductions are evident; first, the training in mathematics is no better than the training in other subjects which are taught from this view point; second, mathematics should be taught as a tool. This may be done in two ways; first, by the use of such methods as those suggested by Miss Hart in School Science and Mathematics for last November and December; and second, by the use of all possible practical applications.

The purpose of this article is to indicate the results of a little study in search of really practical problems.

In Surveying. Gillespie's Surveying, edited by Staley, devotes considerable space to surveying with the chain only and contains many good problems that are not essentially different from many that we are accustomed to give, except for their direct practical bearing. The following are examples:

I. *Calculation of irregular areas.* When areas are calculated by offsets, it is sometimes possible to place these offsets at regular intervals. The following rule is given: "To the half sum of the initial and final offsets add the sum of all the intermediate offsets and multiply the sum by the common distance between offsets." Let the geometry class give proof.

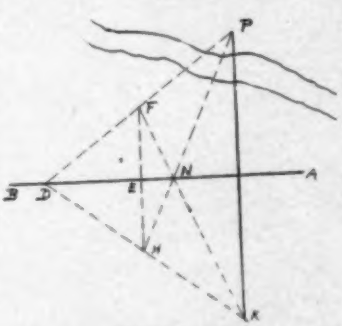

FIGURE 1.

II. *The passing of obstacles.* It is necessary to project a line beyond a building or obstacle of some kind. Solutions and proofs may be required of the class.

III. *Construction of perpendiculars and parallels,* such as to drop a perpendicular to a line from an inaccessible point, to

drop a perpendicular from a point to an inaccessible line, and to run a line through a point parallel to a given inaccessible line. Figure I. To drop a line from the inaccessible point P to line AB. Draw FE perpendicular to AB at an arbitrary point and of any length. EH=EF. Point D is obtained in lines PF and AB; next point N in HP and AB; next in K in DH and FN. PK is perpendicular to AB. Why? (Figure II.) To run a line through point P parallel to line AB. Take C any point in AP and D any convenient point. Get line AD; PE parallel to AD cutting DC at E; EF parallel to BD cutting BC at F. PF is parallel to AB. Why?

IV. *The measurement of inaccessible distances.*

V. *The dividing and parting of land.* It may be required to cut from a piece of land a triangular field of given area, by a line running through a given point, or by a line running in a given direction.

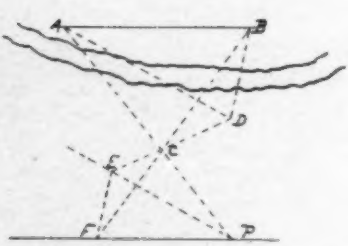

FIGURE 2

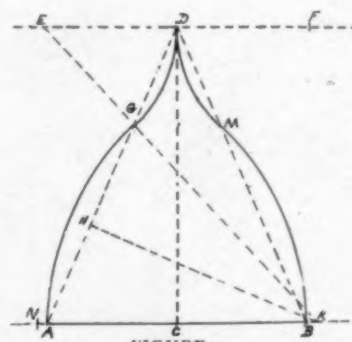

FIGURE 3

In Mechanical Drawing. The boys who take mechanical drawing thoroughly believe in it, and while in the Chicago High Schools the drawing and the mathematics are separate courses, they are so arranged that these boys come to the geometry class after they have had simple geometrical constructions and elementary applications to machinery and architecture. The teacher of geometry may begin with a review of these first constructions and follow these by easy original ones and as the class progresses remind them of others which they have had and require proofs. No proofs were required in the drawing. As many who take solid geometry have had projections, the elementary problems in descriptive geometry may be given to the solid geometry class, if the figures are drawn in perspective. The terms are very simple and can soon be learned when necessary.

The illustrations that follow are all taken from Hanstein's Constructive Drawing.

I. *The Persian Arch.* (Figure III.) Given AB the span and CD the altitude. Draw the isosceles triangle ADB. Divide AD into three equal parts. Draw HK the perpendicular at the first point of division cutting AB at K. Draw KG (G the second point of division) cutting EF at E. EF is parallel to AB through D. K is center and KA radius and E center and ED radius for arcs AGD. On right side of figure FD equals DE and AN equals BK and the arcs drawn. Question: Why do arcs meet at G and M?

II. *Segmental Arches.* (Figure IV.) Given AB the span

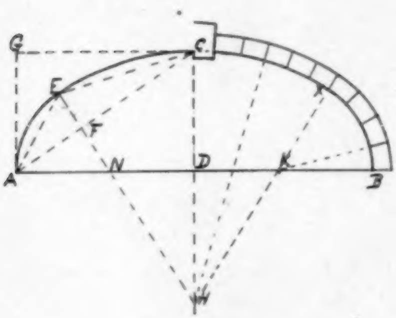

FIGURE 4

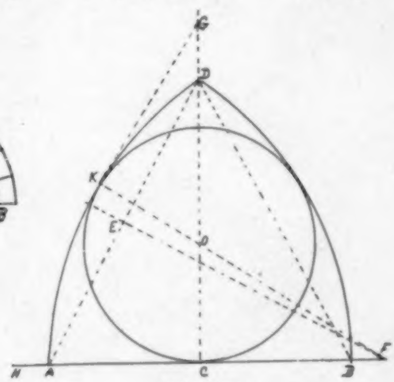

FIGURE 5

and CD the altitude. DC is perpendicular at center of span. Complete the rectangle GADC. Draw diagonal AC. Bisect angles GAC and GCA. Bisectors meet at E. Draw EH perpendicular to AC meeting AB at N and CD produced at H. Make DK equal to DN. N is center and NA radius, H center and HE radius and K center and KB radius for arcs. Question: Why will arcs pass through points E, X and C?

III. *The Gothic Arch and the inscribed circle.* (Figure V.) Given AB the span and DC the altitude, perpendicular at center of AB. Complete the isosceles triangle ADB. Draw EF perpendicular bisector of AD. Make AH equal to BF. F is center and FA the radius and H center and HB radius for sides of the arch. Make CB equal to AF and GK equal to CF. Draw KF cutting DC at O. O is center and OC radius of circle. Questions: Why do arcs meet at D and why is circle tangent to AB and to the two arcs? This construction is interesting in connection with

the locus of centers of all circles tangent to two given equal circles. Also, what must be the relative lengths of the span and the altitude in the Gothic arch?

IV. *Tracery windows.* (Figure VI.) Given diameter AB of the semicircle ADB. AB is divided into four equal parts and DC into three. HK is perpendicular to DC at E, the second point of division, and HF and KG perpendicular to AB. DN equals DE. F is center and FC radius, G center and GC radius, E center and ED radius, H center and HX radius, K center and KY radius, N center and ND radius, and A and B centers and AB radius for the various arcs and circles. Questions enough will be found to occupy a class for some time. The arcs and circles whose

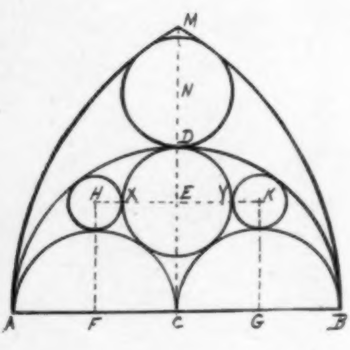

FIGURE 6

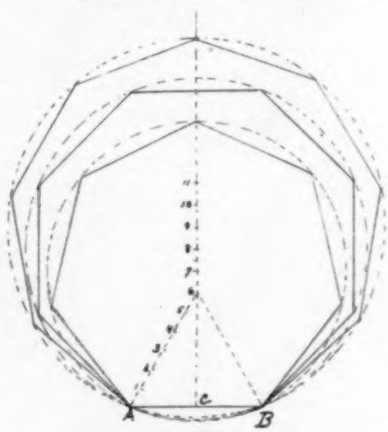

FIGURE 7

centers are CGF and E are frequently used in church windows.

V. *Construction of regular polygons.* (Figure VIII.) Given AB the base of the regular polygon. Construct the equilateral triangle A6B and 6C the altitude. Divide 6A into six equal parts and lay off these parts on C6 extended. If 7 is used as a center and 7A as a radius a circle may be drawn in which AB may be used as a chord seven times; if 8 is used as a center and 8A as a radius a circle may be drawn in which AB may be used as a chord eight times and so on up. (!) The above construction is given with a number of others most of which are capable of proof, but the boys believe them all. It is often interesting to ask the trigonometry class to test the accuracy of some of these. They are frequently startled at the results obtained.

A PROPOSED BIOLOGICAL SURVEY OF NEW YORK STATE.*

By Prof. Charles Wright Dodge,

University of Rochester, Rochester, N. Y.

In 1835, upon the motion of Charles P. Clinch, a representative from New York City, the Assembly passed a resolution directing the Secretary of State to report to the legislature at its next session the most feasible method of obtaining a complete geological survey of the state, including a scientific account of the rocks and soils, a list of mineralogical, zoological, and botanical productions, and the collection and preservation of specimens of the same, with an estimate of the expense of the undertaking. The report was submitted in January 1836, by John A. Dix, then secretary of state, and the act of April 15, 1836, authorized the project, the Assembly unanimously voting an appropriation of $104,000.00 for the enterprise. In 1842, the expenditure of the additional sum of $26,000.00 was authorized. Governor Marcy arranged the plan of the survey and distributed the several departments of the work among a corps of specialists. The report of the survey was published between 1842 and 1854 in seventeen huge quarto volumes with numerous plates, many of them being colored, under the title of the Natural History of New York. Five volumes were devoted to zoology, two to botany, one to mineralogy, four to geology, and five to agriculture. The survey has since been continued along geological and paleontological lines by James Hall and assistants, and by his successor John M. Clarke, the reports up to the present time filling eight large quartos and many octavos. The various specimens collected were used in part to constitute the state museum, some part of the remainder being distributed among the collegiate institutions of the state.

In the survey of 1836, many things which we now recognize as of vast scientific and economic importance received no attention whatever and it is largely to remedy this deficiency and to make our knowledge of the animals and plants of the state more extensive and complete that a new survey is proposed.

In the original survey the larger animal forms from the mam-

*Read at the December, 1905, meeting of the New York State Science Teachers' Association.

mals down to the crustaceans were collected, identified, and described but the lower invertebrates were ignored. We have since come to appreciate the great importance of worms and entomostracans, for example, as food for fishes, and of protozoans in the sanitation of drinking water. The breeding habits and economic value of mammals, birds, reptiles, fishes, mollusks, insects and crustaceans were not investigated, but now we recognize the importance of these various animals as sources of food or clothing, or as beneficent or harmful agents in agriculture, horticulture, or fish-culture, in the rearing of domestic animals and in hygiene.

The botanical work of the survey was mainly the collection and description of the higher plants, the fungi, lichens, and algae not being taken into account. The importance of these forms in furnishing material for many of the strictly scientific problems of biology renders it highly desirable that systematic efforts be made to increase our knowledge of these plants, their distribution, mode of life and economic effects in agriculture, gardening, forestry, fish-culture, and the management of water supplies.

Since the establishment of the office of state botanist in 1867 and of state entomologist in 1882 reports have annually been made by these officers showing that much valuable work has been accomplished, by the former in noting newly discovered species and especially in describing and illustrating the edible and poisonous fungi of the state, and by the latter in investigations mainly upon insects of economic importance.

Then, too, lists containing more or less descriptive matter have been published by the state museum or are in preparation on the mammals, birds, fishes, reptiles and batrachians, mollusks, and crustaceans, but the most of these need revision and amplification, and cannot be made complete until more material has been collected and extensive observations made. The lower plants and animals have as yet received practically no attention; our knowledge of the higher forms is exceedingly incomplete, and of the great majority of aquatic organisms we know little or nothing.

Since the completion of our state survey important work of the kind contemplated has been accomplished in other countries and states by individuals working independently, or under the auspices of institutions, or for government purposes. Reference

will be made in the present instance only to what has been done in the investigation of inland waters. In a paper published by Professor H. B. Ward in Science a few years ago he showed that the most of the countries of Western Europe have each one or more permanent laboratories for the study of fresh-water organisms. Nearly twenty years ago Professor Fritsch, of the University of Prague, established a laboratory on the Black Lake, a small body of water in the Bohemian forest. Previous to this time various investigators had worked in temporary quarters both in the United States and abroad, but no one before Fritsch seems to have had a building especially constructed for the purpose. A similar laboratory is in operation in Finland, and another near Moscow in Russia. Hungary has a station at Lake Balaton, one of the largest bodies of fresh-water in Europe. In France there is a lacustrine laboratory near Clermont-Ferrand. The most famous of all such laboratories is at Lake Ploen in Holstein under the direction of Dr. Zacharias. Each year since its establishment in 1891 a volume of researches has been published by the station and its position has now become sufficiently well assured to warrant the publication of a journal to be issued at regular intervals and to be devoted exclusively to limnobiology. Germany has also two other stations of lesser renown and one has been established in England. The most famous investigator of the biology of fresh water is unquestionably Professor Forel, of the University of Lausanne. His studies of Lake Geneva, three volumes of which have already appeared, furnish a guide to such work in all its branches.

In the United States permanent or summer stations are maintained on Lake Mendota, in Wisconsin; at Chautauqua Lake, in New York State; on Gull Lake, in Minnesota; on Lake Erie at Sandusky and at Put-in-Bay in Ohio; at Turkey Lake, in Indiana; and at Havana, in Illinois. Some of these stations are mainly for teaching, as that at Chautauqua Lake; others are for research exclusively, as the station of the United States Fish Commission at Put-in-Bay, Ohio; and others for both teaching and investigation, as those maintained by the Universities of Ohio, Indiana, Illinois, and Wisconsin, while Massachusetts has a laboratory at Lawrence devoted solely to the study of filtration and the biology of drinking water. In Illinois, Indiana, Michigan, Minnesota and Connecticut biological surveys are in progress

at the present time. In New York no systematic examination of the inland waters have ever been made. It is highly probable that a biological survey of New York will yield most valuable scientific results. Its surface is more diversified than that of any other state in the Union. Its area is over 49,000 square miles. Its borders in part are outlined by the shores of two of the Great Lakes, by one of the largest rivers in the world, and by the Atlantic Ocean. Within its limits are lakes and ponds of every description, fresh-water, brackish water and saline; a unique system of glacial lakes whose fauna is thought to have an intimate relation to that of the sea with which the lakes were at one time connected; shallow lakes and lakes so deep that they are popularly reputed to have no bottom; lakes situated at high as well as lakes at low altitudes; lakes with and lakes without outlets; lakes whose various waters are of widely different chemical composition; isolated lakes and lakes connected in chains or systems; lakes fed by rivers or smaller streams as well as lakes whose water comes from springs. Its rivers are almost as varied as its lakes. Some of the systems empty into the Great Lakes while others flow to the sea. The great tidal Hudson offers every degree of salinity. In the Niagara River with its falls and gorge, organisms live under conditions scarcely paralleled in the world. Mineral springs in great variety offer nearly unexplored fields for investigation. A great canal which traverses the state from east to west furnishes a habitat unlike that found anywhere else in the United States. Immense swamps and marshes thousands of acres in extent, harbor organisms concerning which there is much to be learned. The islands in the Great Lakes, in the inland lakes, and in the ocean offer inviting fields for exploration.

Its surface extending 300 miles from north to south and 326 miles from east to west presents altitudes from sea-level to over 5000 feet, including many of the highest peaks east of the Rocky Mountains. There are two mountain regions, one in the north-eastern and one in the south-eastern part of the state. Caves and subterranean passages in considerable number are to be found whose biological conditions are unknown. The condition of the land varies from that of the thickly populated cities to that of the unexplored forests; land which has been occupied and settled for nearly three centuries and land which has but recently been cleared by the settler. Every variety of soil is represented,

sand, clay, and rock, and the climatic conditions are such that in certain parts of the state plants and animals flourish which are characteristic of the flora and fauna of the Carolinas. No fewer than three life zones, as they are called, are represented in New York, the boreal, the transition and the upper austral, each zone being one of the seven transcontinental belts characterized by a natural grouping or distribution of plants and animals. In respect to number of such zones New York is surpassed by but two of the states east of the Rocky Mountains, viz: North and South Carolina; most states having not more than two zones. While the transition zone occupies the greater part of the state, the boreal is represented in the Adirondacks, the Catskills, and in the high lands of the south-western section. The austral zone sends a long arm up the valley of the Hudson River to Lake George, while another extension from the Mississippi Valley region reaches from Buffalo to Syracuse extending back from the shores of Lake Ontario for a distance of about 30 miles. The extent and variety of our fauna and flora then are unusual.

It is therefore proposed that a survey be inaugurated in accordance with the following tentative suggestions:

Its object shall be (a) to study the biology of the fauna and flora of the state, especially of the aquatic organisms, including their structure, habits, food, distribution, variations, adaptations, ecological relations and economic importance; (b) to investigate such sanitary problems of a biological nature as may arise concerning the lake and river waters used by the cities, villages, and towns of the state; (c) to study lakes with reference to the propagation of fish.

In its organization the survey should properly be under the control of the State Division of Science, and the members of the survey should be equipped by training and experience to serve in field, museum and laboratory; the regular staff performing the most of the work, specialists being engaged only for the purpose of monographing certain groups of organisms or for some particular service of like nature. If the survey could be recruited from the faculties of the universities and colleges of the state, competent investigators would be enlisted, a wider interest in the work aroused, and much expense saved for apparatus, field equipment, books, etc. The most important work would fall to the field parties, and each of these ought to be in charge of a

biologist of sufficiently wide interests and attainments to be able to direct investigation along both botanical and zoological lines, that is, to supervise the study of the special problems assigned to his assistants while he at the same time keeps the general work of the party progressing. As assistants it would seem desirable to engage as far as feasible, the instructors and advanced students in biology in the colleges and universities, as well as competent high school teachers. Many would be glad of the opportunity to do the work required in return for the experience gained. The field work would necessarily include the collection, not only of biological facts and specimens, but of physiographic, chemical, and meteorological data as well.

The material collected, not only specimens, but also notes, drawings, and photographs, should belong to the State Museum and should be added to that already deposited there, and all interesting specimens should be displayed in proper exhibition cases. In addition to the skins of birds and mammals, and the bodies of animals which are seen in conventional museums, there should be collected as many things as possible that show facts about the habits and mode of life of organisms such as specimens of male, female, and young of each kind of animal, the larval forms, eggs, egg-cases and nests, parasitic and pathological conditions, examples of the depredations committed by noxious forms, the vegetative and the reproductive stages of plants in cases where these are unlike or markedly different, as in many algae and fungi. If any material can be obtained in sufficient quantity small collections, with the specimens properly named, should be distributed to the schools throughout the state for use in teaching the biological sciences. If injurious forms, like the gipsy moth in its various stages for example, could be made generally known, especially in the lower schools, much harm to the state at large could probably be avoided by putting people on their guard against an invasion of pests which is certain to come within a short time.

The reports of the survey should be published in suitable form using the best class of illustrations where any at all are required. These publications should be distributed liberally throughout the state, especially to schools, and the district schools and those in small towns ought to be remembered in the distribution. Groups of popular interest should be treated in such manner as to attract the general reader, and the identification of species made as easy

as possible by the use of analytical keys in which technical terms are avoided to as great an extent as is consistent with accuracy.

The cost of the survey would depend upon the nature and extent of the work undertaken. In Illinois the annual expense at present is about $10,000, and in Minnesota it is estimated at $10,000 to $20,000. In each of these states the work is in the hands of a staff of trained investigators who are paid for their services.

It is now fifty to sixty years since the different biological branches of the original Natural History survey were completed. In that time not only has the territory covered undergone great changes due to settlement of the land, destruction of the forests, drying up and filling in of water courses, extension of agricultural and manufacturing operations, increase of population of cities, towns and villages, but our knowledge of plants and animals has also grown. With increasing knowledge a multitude of problems has arisen in morphology, physiology, distribution, variation, adaption and evolution, and the scientific point of view with respect to organic nature has changed entirely from the position it occupied at the time the survey was made. The object of the proposed survey is not so much merely to make additions to the list of plants and animals known to live within the borders of the state as it is to increase our knowledge of the habits and the biological and economic importance of these organisms. It is most essential therefore, that if the state of New York wishes to retain a leading position in educational and scientific matters it should do more than it is now doing in the study of its fauna and flora.

A SOUTHERN CALIFORNIA ROSEBUSH

TESTING THE ACIDITY OF MILK.

By H. H. Lyon,

Bainbridge, N. Y.

Many high schools find it expedient to listen to the demands of the agriculturist in planning their work in science. The following experiment has been arranged for classes in a school where the dairy business is a leading industry. It is a good experiment for any locality, as it relates to milk, an article of diet universally used.

Very soon after milk has been drawn from the udder of the cow it becomes slightly acid, as may be shown by the test with litmus paper. The sugar of milk easily breaks down and forms lactic acid. This acid development proceeds considerably before even an expert handler can detect it by the taste or the odor. As soon, however, as the acid development has reached 0.2 of one per cent, it has come to the danger limit, and the milk will sour very rapidly. Even 0.3 of one per cent can seldom be detected by the sense of taste or of smell, but 0.2 per cent of acid has been adopted as the dividing line between sweet and stale milk.

A chemical test has been devised, and is in daily use in many creameries, and it may be of use in the household. Its practical application in the creamery is, at least, fourfold: First, to select good milk for purchase, and to determine whether it is safe to pasteurize the milk, the standard being as noted above. Second, to test cream for the purpose of finding when it has reached the proper acidity for churning, that being usually about 0.5 per cent acid. Third, to find if two or more lots of cream or milk may be safely mixed without injury to either, a difference of about 0.2 per cent in the acidity of cream allowing the mixing, but a greater difference being prohibitive. Fourth, to test the acidity of whey when it is to be used for making sugar of milk, etc.

The test is based on the chemical combination of sodium hydrate with lactic acid, the reaction being as follows:

$$\begin{array}{ccccccc} HC_3H_5O_3 & + & NaOH & = & NaC_3H_5O_3 & + & H_2O. \\ \text{Lactic acid} & + & \text{Sodium hydrate} & = & \text{Sodium lactate} & + & \text{water.} \end{array}$$

Manufacturers of dairy supplies have prepared a small tablet,

in which is incorporated a definite quantity of sodium hydrate and a small amount of phenolphthalein indicator. The tablet is manufactured according to directions given by Prof. Farrington of the Wisconsin Agricultural College, and each one contains an amount equal to 3.8 cubic centimeters of decinormal alkali.* As a normal solution of lactic acid contains 90 grams of acid to the liter, or 9 grams in a decinormal solution, one c.c. $\frac{n}{10}$ contains .009 grams acid. The specific gravity of milk is 1.032. Ten tablets are dissolved in 100 c. c. water. One c. c. of this solution contains 0.38 c. c. decinormal alkali, it being formed, as indicated above, by the solution of one tablet 3.8 $\frac{n}{10}$ alkali) in ten c. c. water. One c. c. of the solution will therefore neutralize $.009 \times .38 = .0034$ grams lactic acid. In practice, 20 c. c. of milk are taken and tablet solution is added until the pink color of the phenolphthalein appears, faintly, indicating that the milk has ceased to be acid.

To determine the percentage of acid in milk: Take 20 c. c. of milk, neutralize with decinormal alkali. Multiply the number of c. c. of tablet solution taken, by .0034 and divide by the number of grams of milk taken (grams of milk = c. c. $\times$ 1.032). For example: 20 c. c. of milk require 12 c. c. of tablet solution to neutralize the acid. Required the per cent of acidity of the milk.

$$\text{Solution: } \frac{12 \times .0034}{20 \times 1.032} = .0019+ = .19\%.$$

This would indicate a good sample of market milk, though nearing the danger point of acidity.

The tablet solution should not be over eight or ten hours old, but the tablets will keep indefinitely. Professor Wing's book, "Milk and Its Products" (The Macmillan Company) devotes several pages to this subject, and a little pamphlet issued by D. H. Burrell & Co., Little Falls, N. Y., which can probably be had for the postage, gives directions for making a test.

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* These alkaline tablets are listed at $1.00 per thousand or 50 cents per hundred. They can be purchased from D. H. Burrell & Co., Little Falls, N. Y.

MOUNT HAMILTON, CALIFORNIA—LICK OBSERVATORY

THE GRAPH OF $Y=X^2$.

By Fannie Webster,

High School, Binghamton, N. Y.

In drawing the graph of an equation it is customary to give unlimited "slide" to x but to restrict the "slant" to 0° and 180°. The equation $y=x^2$, is then pictured as a parabola in the real plane, symmetrical in regard to the y axis, with its vertex at 0,0, Fig. 1.

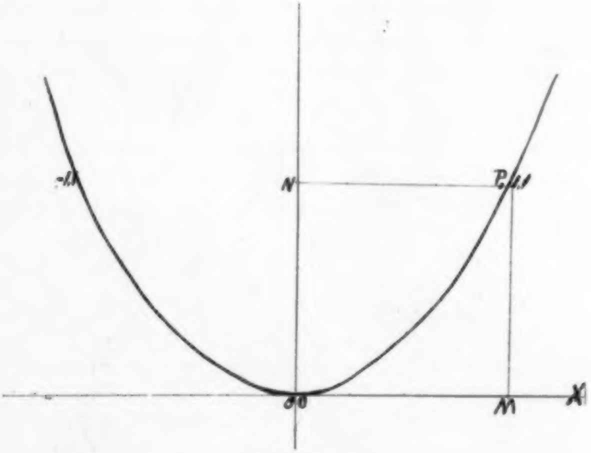

FIGURE 1

Occasionally some one ventures to make the slant 90° and 270°, then the parabola appears in a plane passing through the y axis

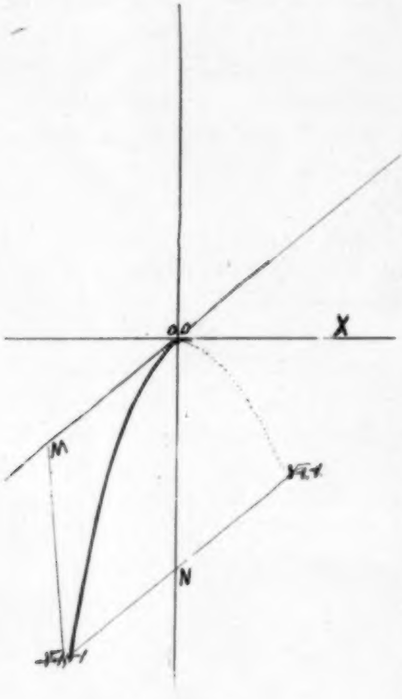

FIGURE 2

perpendicular to the real plane; the vertex remains at o, o, but the parabola extends in the direction of $-y$. Fig. 2.

I have been curious to see what could be obtained by letting the slant of x vary continuously from 0° to 360°, and have found the result quite interesting; possibly others may be interested in it.

Let OX be any fixed line in space, and OY a fixed line, normal to OX.

Let OM represent the independent variable, x changing in magnitude from 0 to ∞, and in direction from coincidence with OX to coincidence with OX again, revolving in the plane to which OY is normal.

Let ON represent the dependent variable, y, its magnitude equal to the square of the magnitude of x, and its direction such that it is always normal to OM and the angle YON always twice the angle XOM.

Let P represent the point x, y. For any given "slide" of x OM and ON would be fixed in length and, since the angle MON is always $+90°$, the distance OP would be constant, and varying the "slant" would cause the point P to move on the surface of a sphere.

Let the "slide" of x be 1, the slide of y will also be 1, the distance OP will be $\sqrt{2}$ the angle MOP will be 45°, the angle PON will be 45°, and these conditions will not be affected by changing the *"slant"* of x.

Construct a sphere with O as a center and $\sqrt{2}$ as a radius. Let the axis OX be directed to the *left* and the axis OY be di-

rected *up*, the real plane facing away from us, that OM and ON may revolve in a positive direction and keep P in the surface of the hemisphere which we are facing.

	x	y
$P_0 =$	$(-1)^0$	$(-1)^0$
$P_1 =$	$(-1)^{\frac{1}{12}}$	$(-1)^{\frac{1}{6}}$
$P_2 =$	$(-1)^{\frac{1}{6}}$	$(-1)^{\frac{1}{3}}$
$*P_3 =$	$(-1)^{\frac{1}{4}}$	$(-1)^{\frac{1}{2}}$
$P_4 =$	$(-1)^{\frac{1}{3}}$	$(-1)^{\frac{2}{3}}$
$P_5 =$	$(-1)^{\frac{5}{12}}$	$(-1)^{\frac{5}{6}}$
$P_6 =$	$(-1)^{\frac{1}{2}}$	(-1)
$P_7 =$	$(-1)^{\frac{7}{12}}$	$(-1)^{\frac{7}{6}}$
$P_8 =$	$(-1)^{\frac{2}{3}}$	$(-1)^{\frac{4}{3}}$
$*P_9 =$	$(-1)^{\frac{3}{4}}$	$(-1)^{\frac{3}{2}}$
$P_{10} =$	$(-1)^{\frac{5}{6}}$	$(-1)^{\frac{5}{3}}$
$P_{11} =$	$(-1)^{\frac{11}{12}}$	$(-1)^{\frac{11}{6}}$
$P_{12} =$	(-1)	(-1)
	etc.	

Let M′ and N′ denote the points where the prolongations of OM and ON would pierce the surface of the sphere, then P′ will always be midway between M′ and N′ on the arc of the great circle connecting them.

By giving x different values, constructing a table, and locating the points, we obtain the curve represented in Fig. 3.

Turning the sphere and constructing the other half of the curve, we find it perfectly symmetrical with regard to the y axis. Fig. 4. This is what I consider the locus of the point P. when $y=x^2$, and x is equal to 1 of varying quality. If now the curve representing varying magni-

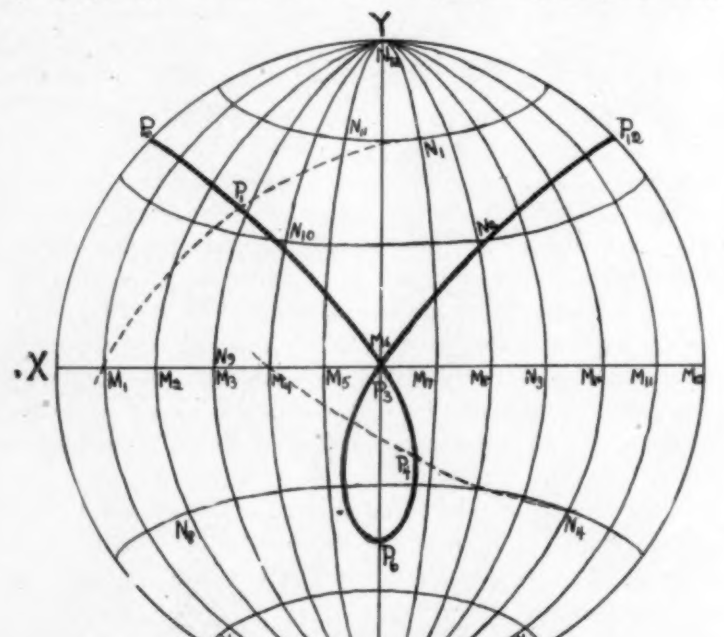

FIGURE 3

tude of x, (the positive branch of the parabola in Fig. 1) be allowed to revolve about O as a pivot so that the point 1,1, follows the curve of Figs. 3 and 4,, the surface generated will be the complete graph of the equation $y=x^2$, when x is unlimited in magnitude and direction.

As the semi-parabola revolves, it may be well to notice the direction in which the plane faces at different points. Facing away from us at the start it gradually turns so that at $(-1)^{\frac{1}{4}}$, $(-1)^{\frac{1}{2}}$ it is facing upward; at $(-1)^{\frac{1}{2}}$, (-1), it is facing to the right; at $(-1)^{\frac{3}{4}}$, $(-1)^{\frac{3}{2}}$, it is facing downward; at (-1), $(+1)$, it is facing forward; at $(-1)^{\frac{5}{4}}$, $(-1)^{\frac{5}{2}}$, up; at $(-1)^{\frac{3}{2}}$, $(-1)^{3}$, to the left; at $(-1)^{\frac{7}{4}}$, $(-1)^{\frac{7}{2}}$, down; at $(+1)$, $(+1)$, back (away from us).

I should be glad if others would work out this and other equations by the same method, and verify my results. I find that $y = ax^n + b$ can easily be plotted by this method, the location of the center of the sphere being determined by b, the directrix being determined by n, and the generatrix by a and n. I have not yet mastered *complete* equations of higher degree than the second. There is plenty of room there for experiment and investigation.

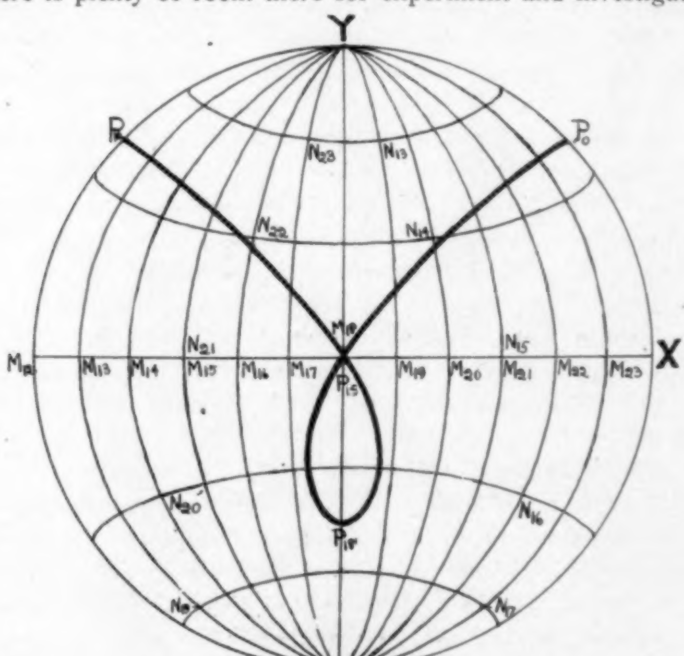

FIGURE 4

RECENT ADVANCE IN ORGANIC CHEMISTRY.*

By Dr. Louder W. Jones,
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Organic chemistry has lost most of the mystery which early chemists associated with it. The theory of vital force has long since been abandoned. At the present time we consider organic chemistry "as a branch of pure chemistry" which must receive separate treatment because of the great number of carbon compounds. It has been estimated that more than 150,000 organic substances are described in the literature. This vast number is growing rapidly. In 1827, while Gmelin was engaged in writing his handbook, he requested chemists to cease their discoveries in order that he might complete his work. Two years later after it had been discovered that pyrouic acid and cyanuric acid were identical, Wöhler w rote to Liebig: "Gmelin will say, 'Thank God, one acid less.'"

A review of the history of chemistry during the nineteenth century will show that many of the most important battles were waged in the realm of organic chemistry. The decisions reached in the study of carbon derivatives were applied in many cases with great success to the compounds of other elements. The fundamental guiding hypotheses of organic chemistry have been: (1) The Atomic Hypothesis; (2) The Molecular Hypothesis; (3) The Valence Hypothesis. By a careful study of reactions and methods of synthesis, it has been possible for chemists to agree upon a graphic formula for almost every organic compound. In terms of the three hypotheses just mentioned, these formulae represent the manner in which the atoms in the molecules are linked together by virtue of their various valences, and in a symbolic way, picture to us the past, present, and future of the molecules concerned.

At the present time, it has become customary to clap the lantern in the face of every old theory, and demand its passport. We are growing skeptical, and have set about to examine the speculative foundations which hold the vast superstructure of modern chemistry. Theories have been deprived of their laurels and degraded to the rank of hypotheses; so called laws, upon

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closer scrutiny, have turned out to be mere hypotheses; with apologies upon our lips, we speak of atomic weights and molecular weights.

In thinking over the various attitudes which are taken at present concerning the atomic hypothesis, it seemed to me that much confusion has arisen from the fact that some chemists would have us believe that the atomic hypothesis, as it stands today, is Dalton's hypothesis as he proposed it early in the nineteenth century. Nothing can be more erroneous than this view. A superficial glance at the history of the hypothesis will show that, during the century, it has changed by a process of dialectics, and is, today, something entirely different from Dalton's hypothesis. In a large measure the Molecular Hypothesis has usurped the authority in chemistry; at the present we define atoms in terms of molecules. It is doubtful whether any other definition is adequate or possible.

Dalton was accustomed to use square blocks of colored wood to illustrate the workings of his hypothesis. The story is told, that, in an examination he once asked his pupils to give a definition of the term atom. One pupil said: "Atoms are square blocks of wood invented by Dr. Dalton." Today there are certain busybodies who caution us against the belief that atoms "are square blocks of wood invented by Dr. Dalton." They assure us that atoms really do not exist, that no one has ever seen or weighed an atom; and by various circuitous roads endeavor to lead us to an appreciation of the fact that we are dealing with an hypothesis, a creation of our own imaginations, which however is very fortunately chosen, since it "explains" and relates, in such a beautiful and wonderful way, the many isolated facts of our experience.

A far more subtle kind of skepticism pervades the writings of certain prominent men, whose names we use to conjure with. Those who caution us against Dalton's blocks say to us, "Put not your faith in material atoms." These men, however, have keener weapons to strike with. They say to us, "Put not your faith in the atomic hypothesis," or as Ostwald expressed it in his address, "Die Ueberwindung des Wissenschaftlichen Materialismus," "Thou shalt not make unto thyself any graven image or likeness. Our problem is not to view the world in a more or less distorted mirror, but as immediately as the constitution of our minds will permit us to do."

These men assert that the step from the conservation of mass, a physical law, to the conservation of matter, a metaphysical axiom, is the root of all evil. When one has allowed himself to swallow this with impunity, he has given himself over into the hands of countless hypotheses.

To illustrate the attitude of these men more fully, let me make one or two quotations from Ostwald's "Die Schule der Chemie." This interesting book is an elementary text-book of chemistry, written in the form of dialogue between pupil and teacher. In the midst of a discourse concerning the nature and purpose of hypotheses, and their value in science, the pupil asks:

Pupil.—But couldn't we get along without them?

Teacher.—Certainly we could. But people nowadays are so accustomed to hypotheses, the atomic hypothesis included, that they feel a great inconvenience when they have to hold the facts without their help. Therefore, they will not dispense with them.

In another part of the book the conversation returns again to the atomic hypothesis and combining weights. The pupil says:

Pupil.—I thought that these numbers must have a *deeper* significance by means of which the law of combining weights might be *explained*.

Teacher.—What is there in the law that is not clear to you?

Pupil.—It does not exactly lack clearness to me, but I thought that there might be something peculiar back of the fact that such a remarkable law exists.

Teacher.—O, that's it, is it? To say the least, that is a very childish way of thinking; just as the peasant thought, when someone had tried to explain the locomotive to him. He said, "I understand all of that, but tell me, where is the horse which draws all of these coaches?"

Pupil.—Ha! ha! ha! That *was* stupid, to be sure.

Teacher.—Not so very. He had not experience to tell him that coaches could be set in motion without a harnessed horse, and he thought, therefore, that he could understand the locomotive only after someone had shown him the hidden horse. For one hundred years chemists even have assumed just such a hidden horse to be concealed in the law of combining weights.

Pupil.—A horse! What do you mean by that?

Teacher.—I mean it figuratively, of course. I mean that people have felt just such a need of assuming a cause of some

kind for the law of combining weights, because, without it, they could not picture to themselves that such a law could exist; just as the peasant could not imagine that a train could be set in motion without a horse.

Pupil.—What does the chemical horse look like?

Teacher.—You know already. *It is the atoms.*

I think these quotations will make it clear to you what I mean by this keener form of skepticism. We are urged to abandon, if possible (and it seems possible to these men), the material or mechanical way of viewing the universe. They would have us substitute energy for matter, since it holds matter, and not matter it, as we have been accustomed to think. In other words, energy is the reality in all things. When we urge the great accomplishments which have been brought to pass by the systematic use of the mechanical mode of thinking, these men reply, "Do not allow yourself to be bribed by results, however brilliant."

What the outcome of these desires will be, remains to be seen. Our present views concerning matter are in a state of flux and as yet, the final goal cannot be predicted.

The valence hypothesis has gone through vicissitudes no less numerous than those through which the atomic and molecular hypotheses have passed. I wish I had time to follow the historical development of the valence hypothesis. I must, however pass over the electro-chemical theory of Berzelius, with its polar atoms, its dualism, and its belief in unchangeable compound radicals. The substitution theory of Dumas (1834) which superseded the theory of Berzelius. The various type and nucleus theories of Dumas, Laurent and others, until we come to the type theory of Gerhardt and Laurent, which in a certain way included all that was of value in the preceding theories.

All organic compounds according to this theory fell into certain mechanical types of which there were four:

TYPES.

$$\begin{matrix} H \\ H \end{matrix} \qquad \begin{matrix} H \\ Cl \end{matrix} \qquad \left.\begin{matrix} H \\ H \end{matrix}\right\} O \qquad \left.\begin{matrix} H \\ H \\ H \end{matrix}\right\} N$$

EXAMPLES.

$$\left.\begin{matrix} H \\ CH_3 \end{matrix}\right\} \qquad \left.\begin{matrix} Cl \\ CH_3 \end{matrix}\right\} \qquad \left.\begin{matrix} C_2H_5 \\ H \end{matrix}\right\} O \qquad \left.\begin{matrix} CH_3 \\ H \\ H \end{matrix}\right\} N$$

As this theory developed it became necessary to introduce complexities; condensed types arose:

Thus

$$\begin{matrix} H_2 \\ H_2 \end{matrix} \qquad \left.\begin{matrix} H_2 \\ H_2 \end{matrix}\right\} O_2 \qquad \left.\begin{matrix} H_3 \\ H_3 \end{matrix}\right\} O_3$$

$$\left.\begin{matrix} H_2 \\ H_2 \end{matrix}\right\} O_2 \qquad \left.\begin{matrix} C_2O_2'' \\ H_2 \end{matrix}\right\} O_2 \qquad \left.\begin{matrix} SO_2'' \\ H_2 \end{matrix}\right\} O_2$$

Oxalic acid Sulphuric acid

$$\left.\begin{matrix} H_3 \\ H_3 \end{matrix}\right\} O_3 \qquad \left.\begin{matrix} C_3H_5''' \\ H_3 \end{matrix}\right\} O_3 \qquad \left.\begin{matrix} PO''' \\ H_3 \end{matrix}\right\} O_3$$

Glycerine Phosphoric acid

Then through Kekulé mixed types were introduced.

TYPES.

$$\left\{\begin{matrix} H\,Cl \\ \left.\begin{matrix} H \\ H \end{matrix}\right\} O \end{matrix}\right. \qquad \left\{\begin{matrix} H\,H \\ \left.\begin{matrix} H \\ H \end{matrix}\right\} O \end{matrix}\right. \qquad \begin{matrix} \left.\begin{matrix} H \\ H \\ H \end{matrix}\right\} N \\ \left.\begin{matrix} H \\ H \end{matrix}\right\} O \end{matrix}$$

EXAMPLES.

$$\left\{\begin{matrix} H \\ \left.\begin{matrix} SO_2'' \\ H \end{matrix}\right\} O \end{matrix}\right. \qquad \begin{matrix} \left.\begin{matrix} H \\ H \\ CO'' \end{matrix}\right\} N \\ \left.\begin{matrix} CO'' \\ H \end{matrix}\right\} O \end{matrix}$$

Sulphurous acid Carbonic acid

Kekulé in 1857 called attention to the fact that in these condensed and mixed types, the two parts could be held together only by a polyatomic (now polyvalent) atom or radical. The polyatomic atom or radical may replace two, three or more of the hydrogen atoms of the types.

Thus, Kekulé says, water itself may be regarded as two molecules of the type hydrogen in which *one atom of oxygen replaces two atoms of hydrogen.*

$$\begin{matrix} H\,H \\ H\,H \end{matrix} \qquad \left.\begin{matrix} H \\ H \end{matrix}\right\} O$$

He saw clearly that a "monatomic element or radical could never hold two molecules of a type together;" that a diatomic atom or radical may hold together two molecules of a type, while a triatomic atom or radical may hold three.

In an account which Kekulé published in 1858, he set forth clearly the theory of valence.

Kekulé assumed that the atomicity or valence of an atom is a

fundamental property which is just as constant and invariable as the atomic weight itself. In the case of compounds which demand more units of affinity than are consistent with the valences of the atoms concerned, he assumes a certain attraction between the molecules as a whole which led to the conception of molecular compounds.

Kekulé assigned to carbon the invariable valence of four, and accounted for the numerous carbon compounds by making certain other assumptions concerning the nature of the carbon atom.

As you know it soon became impossible to maintain that the valence of every atom is invariable. Until quite recently, however, the authority of Kekulé and the overwhelming success in carrying out the theory of structure upon the basis of quadrivalent carbon, has barred out all attempts to show that the valence of carbon may vary. The same is true of the bivalence of oxygen.

Since 1891, Dr. Nef at the University of Chicago has been engaged in the study of various organic compounds which he has shown to be derivatives of bivalent carbon. At the beginning of these investigations, the only compound which was considered to be a probable bivalent carbon derivative, was carbon monoxide. $C{=}O$. It was looked upon as a quadrivalent carbon compound, $C{\equiv}O$, it became necessary to assume quadrivalent oxygen, and chemists did not fancy that either.

All attempts to isolate the simplest hydrocarbon derivative of bivalent carbon $\begin{matrix}H\diagdown\\H\diagup\end{matrix}C$, methylene failed. Dr. Nef has shown that quite a number of substances must be regarded as derivatives of this methylene. Thus:

Prussic acid, $HN{=}C\,]$
Theisocyanides, $RN{=}C\,]$
Fulminic acid, $HON{=}C\,]$
Di iodo acetylidine, $I_2C{=}C\,]$

All of these compounds are poisonous, have unpleasant odors and are chemically extremely reactive. The action of various reagents takes place by the addition of groups of atoms, or single atoms, to the unsaturated bivalent carbon atom, just as phosgene results by the action of chlorine upon carbon monoxide.

$$O{=}C\,] + \begin{matrix}Cl\\|\\Cl\end{matrix} = O{=}C\begin{matrix}\diagup Cl\\ \\ \diagdown Cl\end{matrix}$$

On the basis of numerous experiments, Dr. Nef has been led to the conclusion that all reactions in organic chemistry are, in reality, addition reactions, which depend upon the formation of intermediate unsaturated bodies, in many cases bivalent carbon radicals, which cannot be isolated because of their extreme reactivity. He believes that the old theory of substitution which has prevailed in Chemistry since the time of Dumas (1834) must be replaced by a newer theory of dissociation (non electrolytic).

Through the experiments of Dr. Gomberg we are presented with facts which seem to require trivalent carbon for their explanation. In the early part of the nineteenth century, many attempts were made to isolate organic radicals. It was believed at one time that a radical methyl CH_3 had been isolated. It was found, however, that the compound had a molecular weight twice as great as this radical required, and that two radicals CH_3 had united

$$2\ CH_3 = \begin{matrix} CH_3 \\ | \\ CH_3 \end{matrix}$$

to form ethane.

Dr. Gomberg has obtained a compound called triphlenyl methayl, which he considers to be methyl in which the three hydrogen atoms are replaced by phenyl groups, C_6H_5—

$$\begin{matrix} H\diagdown \\ H\text{—}C \\ H\diagup \end{matrix} \qquad \begin{matrix} C_6H_5\diagdown \\ C_6H_5\text{—}C \\ C_6H_5\diagup \end{matrix}$$

Methyl Triphenyl methyl

This interesting substance was obtained by the action of finely divided metals upon triphenyl methyl chloride.

$$2(C_6H_5)_3\,C - Cl + Zn =$$
$$2(C_6H_5)_3\,C + ZnCl_2$$

In the pure state, it is a beautiful colorless crystalline solid which dissolves in certain solvents to give a yellow solution.

It has been shown that triphenyl methyl alcohol, $(C_6H_5)_3COH$, and triphenyl methyl chloride $(C_6H_5)_3\,Cl$ are distinctly electrolytes and dissociated in solut on. Thus:

$$(C_6H_5)_3\,COH = (C_6H_5)_3C + OH'$$

The group $(C_6H_5)_3C$, according to Gomberg, plays the role of a positive metal in these compounds. This has led to the name carbonium compounds for these substances. Strange to say, methyl alcohol

$$\begin{matrix} H \\ H \end{matrix}\!\!>C<\!\!\begin{matrix} H \\ OH \end{matrix}$$

which might on this basis be called carbonium hydroxide, has no appreciable basic properties.

Recent investigations have shown that the molecular weight of triphenyl methyl is twice as great as the simple formula demands.

$$((C_6H_5)_3\,C)_2, \text{ or } C_{38}\,H_{30}$$

This would indicate that triphenyl methyl had united to form

$$(C_6H_5)_3\,C - C\,(C_6H_5)_3$$

hexaphenyl ethane, just as methyl united to form ethane. But strange to say, a compound called hexaphenyl ethane is known and is not identical with the bimolecular form of triphenyl methyl. This difficulty still remains to be cleared away.

Oxygen, like carbon, has been regarded as invariable in valence. Within the past few years, many organic compounds have been found to contain quadrivalent oxygen.

The history of quadrivalent oxygen may be considered to commence with the work of Friedel 1875. He found at low temperature that dimethyl ether gave a crystalline compound with hydrochloric acid, $(CH_3)_2O$, HCl. He regarded this compound as a possible quadrivalent oxygen derivative.

$$\begin{matrix} CH_3 \\ CH_3 \end{matrix} \!>\! O \!<\! \begin{matrix} H \\ Cl \end{matrix}$$

Most chemists however preferred to look upon it as a molecular compound, rather than to concede that oxygen might have a valence of four.

If it is assumed to contain quadrivalent oxygen, it may be considered as a derivative of a hypothetical compound

$$\begin{matrix} H \\ H \end{matrix} \!>\! O \!<\! \begin{matrix} H \\ OH \end{matrix}$$

which may be called oxonium hydroxide if we carry out the analogy which it has to similar compounds of other elements.

Thus:

H_4 NOH	Ammonium hydroxide
H_4 POH	Phosphonium hydroxide
H_3 SOH	Sulphonium hydroxide
H_2 IOH	Iodonium hydroxide

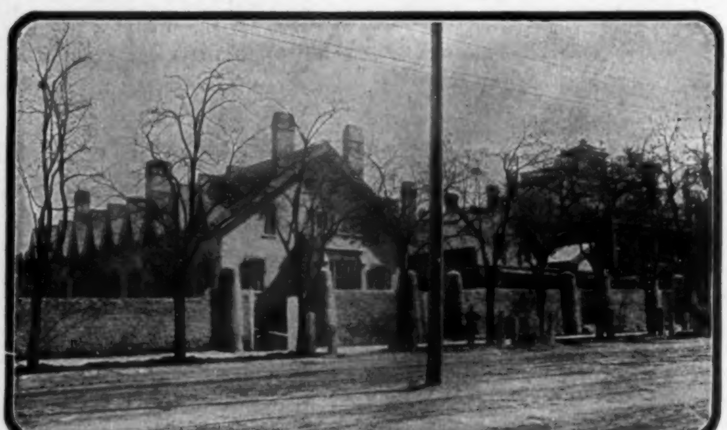
Derivatives of all of these forms are known in organic chemistry. Looked at in this way, the compound of dimethyl ether and hydrochloric acid is a salt.

$$\begin{matrix} CH_3 \\ CH_3 \end{matrix} \!>\! O \!<\! \begin{matrix} H \\ Cl \end{matrix}$$

More recent investigations by Collie and Tickle (1890) and by Baeyer and Villgjer (1901-1902) have shown that oxygen in almost all of its organic compounds is capable of forming salts with certain acids. These salts are not "molecular aggregates," but true derivatives of basic quadrivalent oxygen, or oxonium compounds. Thus Baeyer and Villgjer found that ethers, alcohols, aldehydes, ketones, esters all unite with certain inorganic and organic acids to form crystalline salts which are electrolytes.

Recently, Archibald and McIntosh have studied the action of liquid halogen acids at low temperatures upon acetone ether, alcohol, and similar compounds. Their results show that these acids react to form crystalline salts which have meeting-points ranging from —90° to —120°.

We have therefore, been compelled to come to the conclusion that the valence of carbon or of oxygen may vary. We have bivalent carbon, quadrivalent oxygen. May we not expect to find compounds in which hydrogen has some other valence than one?



TITHING HOUSE, SALT LAKE CITY

THE RELATIVE EMPHASIS TO BE GIVEN PHYSIOLOGY, MORPHOLOGY, ECOLOGY, AND OTHER PHASES OF BOTANY AND ZOOLOGY.*

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That morphology, physiology, ecology, and systematic biology should each receive a place in a high school course in botany and zoology is a theory which at this date no longer needs defense. Their right to consideration is recognized by nearly all instructors, of both collegiate and secondary institutions. The recognition of the importance of economical biology is possibly not quite so general.

What is their relative importance, which is better suited to the minds of high school pupils, how much of a place in the course each deserves is not so uniformly agreed upon.

The question of the relative emphasis which each of these phases should be accorded may be considered from two viewpoints, namely, the relation which each bears to the life of plants and animals, and the disciplinary, cultural, and informational value of each.

Of the several phases to be considered the one which is most obviously connected with the life of the plant, is that of physiology. Life is evidenced by functions. The activities of an animal are almost the first thing the pupil sees. With plants the matter is different. It is rarely that the entering pupil has any conception of a plant as an organism which is as much alive as his own body, and the one way in which to lead him to realize that it is living is to aid him in discovering its activities. He might study minutely the anatomy of every part of a plant and he might know that before he cut it up it was alive because it was capable of growth, but it would still be a relatively lifeless thing till he inquired into its physiology. Let him once demonstrate its exhalation of carbon dioxide, its absorption of oxygen from the air and immediately it becomes a thing possessed of life, akin to himself. A knowledge of the physiology of plants or animals is essential to a right conception of their life.

On the other hand function is determined by structure, and

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structure is affected by function. A right conception of a function cannot be formed without attaining some knowledge of the structure which performs that function. Illumined by physiology, morphology becomes a division of the subject intimately related to the life of either plant or animal.

In ecology the student is brought face to face with the problems which the plant or animal has to meet as it makes and keeps for itself a place in the crowded world. As sociology concerns itself with the general life of humanity, the life of the individual as related to that of the mass, so ecology is constantly concerned with the organism's responses to the conditions which surround it and help or hinder its life.

Systematic biology may not at first thought seem to bear closely upon life. If, however, it be so taught as to develop in the minds of the pupils an understanding of the great relationships of the groups of plants and animals and a recognition of the fact that the development of these great groups has been a response to environmental conditions, they will thereby obtain a comprehensive view of life, a vision of its meaning which can come to them in no other way.

In disciplinary value each has its own advantage. Morphology excels as a means of training in accuracy of observation, in truthful seeing, and, as a means of developing constructive imagination, powers which count for character and for culture. Physiology also demands accuracy of observation, and affords a training in honesty, absolutely strict truthfulness, unsurpassed by that of any other subject in the curriculum. Not the least of its values is its power to develop intellectual independence, to give the pupil the consciousness that he can think for himself, and to train in him that most effective method of thought, the scientific method of inquiry.

Systematic biology has a value all its own in teaching the pupil to classify facts, to recognize the points which seemingly unlike things may have in common and so classify them; it develops in him the ability to classify thought and to generalize, an ability which is most necessary for clear thinking, which makes the difference between a man of information and a man of intellectual power.

In ecology, however, we come to somewhat dangerous ground. Unless the pupil be held constantly in check, the gain in in-

tellectual honesty made in physiology may be all undone by the conclusions too hastily drawn from insufficient evidence. In a subject where so little is absolutely known, where so much is as yet but theory, young pupils are too easily satisfied to state mere speculation as fact, and there is a constant necessity for guarding against careless theorizing which easily leads to a really careless disregard for well-defined truth.

From the point of view of informational value of a sort which lends to culture, somewhat less perhaps can be said for anatomy and morphology than for physiology and ecology, though each has its right to recognition here. The natural history of plants and animals is readily recognized by the world at large, whether by biologists themselves or not, as affording the most interesting kind of information, as tending more to produce a sympathetic attitude towards the plant and animal life than does mere anatomical knowledge. Ecology and physiology related as they are to life are better adapted to arouse in the mind the sympathetic attitude, than are strictly structural studies.

If information is to be regarded, as it unquestionably is, as a legitimate end of education, then economics have a rightful place in the course. Biology has discovered facts the practical application of which has affected the life of humanity as deeply as has any discovery of physics or of chemistry. No teacher of physics could contemplate the teaching of the subject of electricity without developing its economic importance. Why should a teacher of zoology guide his students through a study of the insects and fail to discuss with them their importance as enemies of man or contributors to his happiness? Why should he consider the birds and fail to show their value as insect-enemies when without them vegetable life would be an impossibility? Every pupil has a right to know these facts, not merely to know them but to feel them as a result of his own observations. There can be no surer way of broadening his sympathies, of leading him to that appreciation of life which marks the cultured man. Can any citizen of our country to-day be regarded as a man of culture who is entirely ignorant of the services our government is constantly rendering the nation through the biologists who are spending their lives in its service? The knowledge of the plants and animals and their places in life which systematic biology gives is recognized by all as information which is cultural in its character.

To summarize: Physiology has great disciplinary and informational value and is most intimately connected with life. Ecology such as can be accomplished by high school students is inferior in the first respect but deserves much attention for its informational value and its direct connection with the life of the organism.

Morphology, possessing great disciplinary value and forming the foundation for physiological and ecological studies, is almost as important as those studies themselves.

Systematic botany, for all three reasons deserves its share of attention. Economics, important solely as an informational division of the work, may claim the smallest place.

To attempt to say how much of the course should be devoted to each division of the science would be an absurdity. Physiology requires less time for its demonstration than does anatomy, therefore, though we may conclude that it deserves greater emphasis we must give it less time. To develop anatomy and morphology and, separately, from them, to teach physiology, either at the beginning of the course, would however be a means of over-emphasizing the former subjects. If physiology, as it naturally should, is made to accompany the structural work, then it can receive the emphasis it deserves. For instance, in botany, as roots are studied, osmosis, root pressure, and acidity of roots should be demonstrated. As the structure of the leaf is developed, the processes of photosynthesis and of transpiration must be developed. No piece of anatomical work may be allowed to lack its correlated work in physiology. So only can the structure be related to the life of the plant. Similarly ecology and morphology should go hand in hand. The crab apple's thorny branches, the thistle's spiny veins, the rose's prickly epidermis attain meaning only when the possible uses of these modifications are considered. Similarly these phases should be constantly related in zoological studies.

Let it be emphatically stated, however, that no anatomical or morphological work should be performed which does not bear directly upon the understanding of the functions, either physiological or ecological of the structure in hand or upon its rank in the plant or animal world.

Systematic biology is essential. In botany there is a tendency to give more time to the morphological studies of the types chosen to illustrate the great groups than seems necessary in order to

develop the relationships of the groups and a recognition of the principles of evolution. Some of the time frequently spent upon this work could more profitably be given to field-study and to observations of forms and the learning of facts which touch more closely the life of the pupil, and the knowledge gained from such work would be of a sort which would have a more broadening influence upon the pupil's sympathy with nature and would tend to give him wider interests in life. To learn to know mosses from liverworts and algae from either when he sees them in their natural setting will add more to the pupil's enjoyment of life than will a detailed study of the structure of a liverwort's antheridiophore or of the anatomy of a sea-weed.

In zoology the same principles are to be applied, and as much ecological study of many forms as can be performed without so weakening the work in anatomy as to impair the understanding of function or of rank, should be made a part of the course.

In both subjects, wherever it is practicable, the economic value of form should be noted, and practical application of knowledge gained should be made. Yet this work should be incidental, never receiving disproportionate emphasis. It has been through the practical application of man's long acquaintance with the things of Nature that he has gained supremacy; to omit economics—applied biology—from the course would be to ignore the influence of contact with the plants and animals in the development of our race. Both zoology and botany have accomplished marvelous changes in the life of man—many of the discoveries in both sciences within the last century have had an enormous effect upon the happiness of the race. To ignore this side of the subject would be to scorn a means, not at all to be despised, of arousing a most helpful interest in the subjects and an appreciation of them on the part of the public which unhappily is not infrequently lacking. There are still reforms to be accomplished. The destruction of forests and the wanton killing of birds may be sooner lessened if our pupils learn their value. But because of its lack of disciplinary value, and the tendency which would soon arise to regard man as the centre of the world for whose benefit all other creatures have their being, the economical side of biology is to be given less attention than is any other phase of the subject.


Temple Square
Exposition Bdg.
Board of Trade
The Gardo House or Amelia's Palace
Views in Salt Lake City
Under the Temple Walls
Brigham Young's Grave

BRIGHT ANGEL CAMP AND START DOWN THE TRAIL INTO THE GRAND CANYON—SANTA FE ROUTE

SOME EXPERIMENTS WITH A PIECE OF IRON WIRE.

By John F. Woodhull, Ph.D.,
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A board was chosen a little more than a hundred inches long and about 6 inches wide. Two double binding posts were placed upon this 100 inches apart, between which was stretched a piece of No. 24 iron wire. Copper wires brought the 110 volt direct current to the binding posts.

1. When the current was thrown on without other resistance, the iron wire is heated throughout its entire length to a brilliant red heat and sags down as much as six inches at its center. To straighten the wire while hot it was found to be necessary to draw it through one of the binding posts to the extent of one inch. Hence the wire had been lengthened by 1-100 part of itself.

The temperature is about 1000°. That is, iron expands 1-100 $\times$ 1-1000 = .00001 for each degree. This coefficient of expansion enables us to calculate that the cables of a certain suspension bridge may be one yard longer in summer than in winter. That a certain length of steam pipe expands and contracts one foot each day. That a certain wagon tire is stretched one inch by heat to enable it to be put upon the wheel.

2. 100 inches of No. 24 iron wire offers 1.4 ohms of resistance when cold. If it would remain cold during the above experiment it would pass 80 amperes; $\frac{110 \text{ volts}}{1.4 \text{ ohms}} = 80$ amperes. An ammeter is put in circuit with the iron wire and the current is turned on again as before. The iron heats so rapidly that the needle scarcely gets beyond 30 and quickly passes back to 8 (too quickly to melt any fuse). Heat raises the resistance of the iron wire in this case from 1.4 ohms to 14 ohms; $\frac{110 \text{ volts}}{14 \text{ ohms}} = 8$ a.

3. The 110 volt alternating current was thrown on with all the effects obtained by the direct current but with this additional result that when a resistance of about 7 ohms was added (enough to prevent the iron wire from getting hot) musical tones and a number of overtones were produced which could be distinctly heard all over a large lecture room. These disappeared when the iron was made red hot.

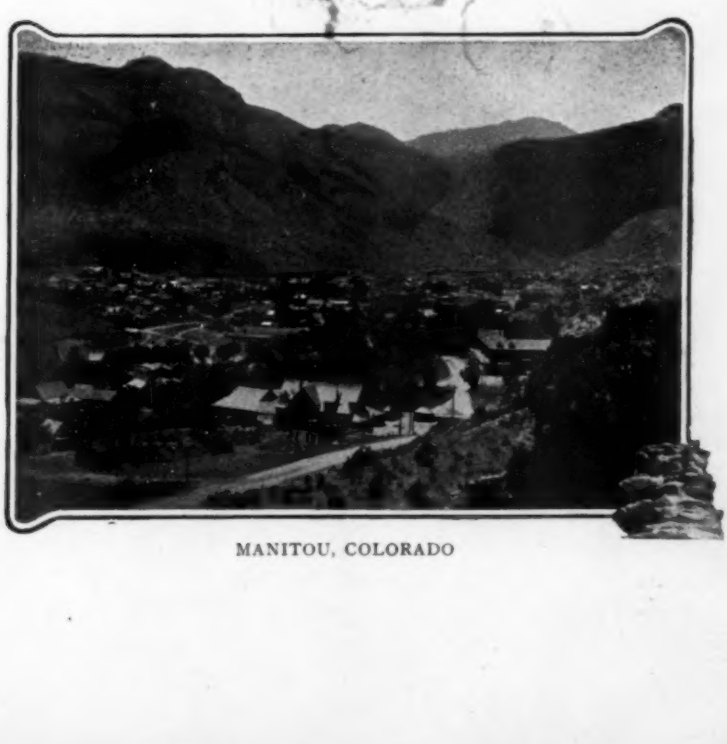
4. A spot on the iron wire is now filed to a thread not larger than No. 30 wire. The current is turned on gradually by means of the rheostat. The spot is now the only part of the wire which glows and, although its real diameter is about that of No. 30 wire, it looks like a bulb one quarter of an inch in diameter. In like manner the filament of an incandescent lamp which may not be larger than No. 30 wire may look as large as No. 16 wire when lighted, and the No. 24 iron wire looked as large as No. 14 wire when brilliantly heated in the first experiment.

Finally current enough is sent through the iron wire to melt it apart at the spot, showing how the wiring of buildings is protected by fuses.

5. A piece of wire is stretched upon a sounding board about 18 inches long and made to change its tone as much as half an octave by throwing on and off a current of three or four amperes while plucking the wire with one's finger.

Incidentally this shows that a "live wire" is "dead" so long as one only is touched.

Thus a piece of iron wire is made to illustrate some teachings in heat, electricity, light, and sound.



MANITOU, COLORADO

PROBLEMS OF WEIGHT BASED UPON CHEMICAL EQUATIONS.

By G. J. Van Buren,
Tuscola, Illinois, High School.

I have been trying to devise some way whereby the difficulty in solving such problems might be overcome, and I think I have succeeded. An example will best explain the method I find to be very comprehensible.

Problem: If in the making of nitric acid I take 6 grams of sodium nitrate, how much sodium sulphate will be formed?

Let us suppose that the acid is made according to the following equation:

$$\begin{array}{ccccc} 6 & & : & x & \\ 2\,Na\,NO_3 & + H_2 & SO_4 = & Na_2\,SO_4 & + \; 2\,HNO_3 \\ \underline{46 + 28 + 96} & & & \underline{46 + 32 + 64} & \\ 170 & & : & 142 & \end{array}$$

Now, having our equation properly stated it is only necessary to find the atomic weight of the sodium nitrate and sodium sulphate, or the substances referred to in the problem.

This is set down under each one respectively. Next put the amount by weight above each of the substances, i. e., the 6 above the sodium nitrate and, not knowing the amount of the sodium sulphate, put an x. Now, between the atomic relation below and the weight-relation above place ratio marks.

The only thing remaining now in order to put it into tangible form is the placing in the same order of the upper ratio at the right o fthe lower one thus: $170 : 142 :: 6 : x$.

A METHOD OF RESUSCITATING WORN OUT DRY CELLS.

When your dry cells have become "dead" do not throw them away until "wet dry cells" have been made of them after the following plan. Removė the paper covering and punch fifteen or twenty holes, three or four mm. in diameter, in the zinc element or cup. Secure a Leclanché jar or other suitable vessei and place the old dry cell in this jar, containing a solution of ammonium chloride. It will be found that this form of cell will be practically as strong as when the dry cell was new.

PROBLEM DEPARTMENT.

PROFESSOR IRA M. DELONG,
University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Solutions and problems will be duly credited to the author. Address all communications to Ira M. DeLong, Boulder, Colo.

ALGEBRA.

12. *Proposed by E. L. Brown, M. A., Denver, Colo.*

$$1^p + 2^p + 3^p + \ldots\ldots + n^p = \frac{n^{p+1}}{p+1} + \frac{p}{2!}\,(1^{p-1}+2^{p-1}+\ldots\ldots+n^{p-1})$$
$$-\frac{p\,(p-1)}{3!}(1^{p-2}+2^{p-2}+\ldots\ldots+n^{p-2})\ \ldots\ldots \pm \frac{p}{2!}(1^2+2^2+\ldots\ldots n^2)$$
$$\mp (1+2+\ldots\ldots+n) \pm \frac{n}{p+1},$$ p being a positive integer.

Solution by I. L. Winckler, Cleveland, Ohio.

We have the identity

$$n^{p+1} - (n-1)^{p+1} = (p+1)\,n^p - \frac{(p+1)\,p}{2!}n^{p-1} + \frac{(p+1)\,p\,(p-1)}{3!}n^{p-2}$$
$$\ldots\ldots\ldots\ldots \pm (p+1)\,n \mp 1$$

Making n in succession $n-1$, $n-2$, ...2, 1, there results

$$(n-1)^{p+1} - (n-2)^{p+1} = (p+1)\,(n-1)^p - \frac{(p+1)\,p}{2!}\,(n-1)^{p-1}$$
$$+\frac{(p+1)\,p\,(p-1)}{3!}\,(n-1)^{p-2}\ldots\ldots \pm (p+1)\,(n-1) \mp 1$$

$$(n-2)^{p+1}-(n-3)^{p+1} = (p+1)\,(n-2)^p - \frac{(p+1)\,p}{2!}\,(n-2)^{p+1}$$
$$+\frac{(p+1)\,p\,(p-1)}{3!}(n-2)^{p-2}\ \ldots\ldots \pm (p+1)\,(n-2) \mp 1$$

....

$$2^{p+1} - 1^{p+1} = (p+1)\,2^p - \frac{(p+1)\,p}{2!}2^{p-1} + \frac{(p+1)\,p\,(p-1)}{3!}2^{p-2} -$$
$$\ldots\ldots \pm (p+1)\,2 \mp 1$$

$$1^{p+1} - 0^{p+1} = (p+1)\,1^p - \frac{(p+1)\,p}{2!}1^{p-1} + \frac{(p+1)\,p\,(p-1)}{3!}1^{p-2}$$
$$\ldots\ldots \pm (p+1)\,1 \mp 1$$

Adding these equations we have:

$$n^{p+1} = (p+1)\,(1^p + 2^p + 3^p + \ldots\ldots n^p) - \frac{(p+1)\,p}{2!}(1^{p-1}+2^{p-1}+3^{p-1}+$$
$$\ldots\ldots n^{p-1}) + \frac{(p+1)\,p\,(p-1)}{3!}(1^{p-2} + 2^{p-1} + 3^{p-2} + \ldots\ldots n^{p-2}) -$$
$$\ldots\ldots \pm (p+1)\,(1+2+3+\ldots\ldots n) \mp n$$

Transposing and dividing by $p+1$ we have :

$$1^p + 2^p + 3^p + \ldots\ldots n^p = \frac{n^{p+1}}{p+1} + \frac{p}{2!}\,(1^{p-1} + 2^{p-1} + 3^{p-1} + \ldots\ldots n^{p-1})$$
$$-\frac{p\,(p-1)}{3!}\,(1^{p-2} + 2^{p-2} + 3^{p-2} + \ldots\ldots n^{p-2})$$
$$+\ldots\ldots\ldots \pm \frac{p}{2!}(1^2 + 2^2 + 3^2 + \ldots\ldots n^2) \mp (1+2+3+\ldots\ldots n) \pm \frac{n}{p+1}$$

Also solved by Orville Price and the proposer.

GEOMETRY.

13. *Proposed by I. L. Winckler, Cleveland, Ohio.*

A series of circles tangent to a given straight line at a given point in the line intersect a given circle. Show that the common chords of the given circle and the series of circles pass through the same point.

I. *Solution by E. L. Brown, M. A., Denver, Colo.*

Let X_1, X_2, X_3, etc., be a series of circles tangent to the line L at the point T, and Y the given circle. The X-series is a system of coaxal circles, having the common radical axis TL. Let the radical axis of X_1 and Y intersect TL in the point P. Now the radical axis of Y and any other one of the X-series of circles will pass through the point P, since in any system of three circles their radical axes taken in pairs are concurrent.

Solved in a similar manner by Eleanora Harris.

II. *Solution by T. M. Blakslee, Ph.D., Ames, Iowa.*

Take contact point as origin and tangent as x axis. Then any one of series is circle r (o, r), and given circle is R (m, n). Their chord is $2mx + 2ny - 2ry - m^2 - n^2 + R^2 = o$. The x intercept of this ray is independent of r. Hence all the chords cut the x axis at the same point.

Also solved by J. Alexander Clarke and the proposer.

15. *Proposed by P. S. Berg, Larimore, N. D.*

If P be the point of intersection of the medians of a triangle ABC, and Q any other point in the plane, then—

$\overline{QA}^2+\overline{QB}^2+\overline{QC}^2=\overline{PA}^2+\overline{PB}^2+\overline{PC}^2+3\overline{PQ}^2$.

Solution by Mary A. Barkley, Sacramento, Cal.

Let F be the mid point of BC and O the mid point of PA, then $\overline{QA}^2 + \overline{PQ}^2 = 2\overline{QO}^2 + 2\overline{AO}^2$; $\overline{QB}^2 + \overline{QC}^2 = 2\overline{QF}^2 + 2\overline{BF}^2$. Adding, there results

(1)......$\overline{QA}^2 + \overline{QB}^2 + \overline{QC}^2 = 2\overline{QO}^2 + 2\overline{AO}^2 + 2\overline{QF}^2 + 2\overline{BF}^2 - \overline{PQ}^2$.

We have also the following relations (2, 3, 4, 5,:

(2)......$2\overline{AO}^2 = 2\overline{PF}^2$.

$\overline{QO}^2 + \overline{QF}^2 = 2\overline{PQ}^2 + 2\overline{PF}^2$, whence

(3)......$2\overline{QF}^2 = 4\overline{PQ}^2 + 4\overline{PF}^2 - 2\overline{QO}^2$.

$\overline{PB}^2 + \overline{PC}^2 = 2\overline{BF}^2 + 2\overline{PF}^2$, whence

(4)......$2\overline{BF}^2 = \overline{PB}^2 + \overline{PC}^2 - 2\overline{PF}^2$.

(5)......$4\overline{PF}^2 = \overline{PA}^2$.

Substituting (2, 2, 4, 5) in (1) we obtain the required result,

$$\overline{QA}^2 + \overline{QB}^2 + \overline{QC}^2 = \overline{PA}^2 + \overline{PB}^2 + \overline{PC}^2 + 3\overline{PQ}^2.$$

Also solved by Orville Price, E. L. Brown, I. L. Winckler, Anna L. Wright.

TRIGONOMETRY.

13. *Proposed by I. L. Winckler, Cleveland, Ohio.*

On the bank of a river there is a column 200 feet high supporting a statue 30 feet high. The statue to an observer on the opposite bank sub-

tends an equal angle with a man 6 feet high standing at the base of the column. Find the breadth of the river.

Solution by A. E. Whitford, Milton, Wisconsin.

Let AB = 6 be the man, AC = 200 the column, CD = 30 the statue, AE = x the breadth of fhe river. Assume that the observer's eye is on a level with the base of the tower. Let angle AEB = Θ, AEC = Φ. then by hypothesis CED = Θ.

$$\text{Now } \frac{AB}{x} = \frac{6}{x} = \tan\Theta,\ \frac{AC}{x} = \frac{200}{x} = \tan\Phi,\ \frac{AD}{x} = \frac{230}{x} = \tan(\Phi+\Theta).$$

Substituting these values in $\tan(\Phi+\Theta) = \dfrac{\tan\Phi + \tan\Theta}{1 - \tan\Phi\tan\Theta}$ and simplifying, we obtain $230\,x^2 - 276000 = 6\,x^2 + 200\,x^2$, whence $x^2 = 11500$ and $x = 107.24$ feet.

Also solved by Merton Watkins, E. L. Brown, F. A. Swanger, Orville Price, R. C. Shellenbarger, Anna L. Wright, I. L. Winckler, T. M. Blakslee, Eleanora Harris.

PROBLEMS FOR SOLUTION.

ALGEBRA.

22. *Proposed by E. B. Escott, M. A., Ann Arbor, Mich.*

If w is any complex root of $x^{13} - 1 = 0$, show that $w + w^3 + w^4 + w^9 + w^{10} + w^{12}$ and $w^2 + w^5 + w^6 + w^7 + w^8 + w^{11}$ are roots of the equation $x^2 + x - 3 = 0$.

Also show that $w + w^5 + w^8 + w^{12}$; $w^2 + w^3 + w^{10} + w^{11}$; $w^4 + w^6 + w^7 + w^9$ are roots of the equation $x^3 + x^2 - 4x + 1 = 0$.

GEOMETRY.

23. *Proposed by L. B. U., Boston, Mass.*

Through A, the point of intersection of two circles, draw any secant intersecting the circles again in M and N. Prove that the tangents to the circles at M and N intersect in a constant angle.

24. *Proposed by R. C. Shellenbarger, Yankton, S. D.*

Inscribe a square within the part common to two intersecting circles.

TRIGONOMETRY.

25. *Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.*

The sides of a triangle are in arithmetic progression with a common difference of one; the greatest angle is double the least. Solve the triangle.

26. *Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.*

A steeple of a church rises 100 feet above the base of the steeple. Two persons are at horizontal distances of 200 feet and 300 feet respectively from the steeple, the steeple appearing to them under the same vertical angle. What is the distance from the ground to the base of the steeple?

DEPARTMENT OF METROLOGY. NOTES.

The opinion of an expert. Alexander Graham Bell has presented, in a 12-page article in the March number of *The National Geographic Magazine*, the substance of his recent testimony before the House Committee, on the reasons why the United States should abandon its obsolete system of inches, tons and gallons. Numerous arithmetical examples in reduction, multiplication, division and specific gravity are given to show the simplicity and the superiority, as a labor saving device, of the metric system over the chaotic one now in use. The argument makes it clear that as our whole system of arithmetic is decimal, our scale must also be decimal.

Dr. Bell's experience in introducing metric measurements in his laboratory was just what every teacher of science could have foretold, and it shows the utter absurdity in the use of it. He says: "The translation of the ordinary measurements into metrical terms, and *vice versa*, involved considerable labor on my part, and it seemed advisable therefore to introduce the metric system into the laboratory and have all measurements made directly in metrical terms. The only question in my mind was whether ordinary workmen, carpenters and mechanics accustomed to the usual methods of measurements, could or would employ the metric system. The result may be of interest to the committee as bearing upon the question of the ability of the common people of America to handle a new system of the kind. No difficulty whatever was experienced in the use of the system, and the total expense involved in the change amounted to a few dollars for the purchase of a set of metrical weights and measures. The same balances formerly employed were equally efficient in weighing by the metrical system, and even the old weights were utilized as supplementary weights, with their value in grams distinctly marked upon them. No change was required in the machinery and tools employed, simply a change in the method of measuring the output. * * * They now use meters, and centimeters and grams and kilograms as if to the manor born, and they are simply common carpenters and mechanics.

"It would not be necessary to throw away the machinery and tools they now have, because generally you would have a sufficient approximation to some exact metrical measurements for practical purposes. We can approximate, say to a sixty-fourth of an inch, or a fraction of a millimeter, which would be near enough to precise figures ordinarily." On the commercial side he says: "In my opinion, the trade and commerce of the United States will be very much promoted by our adoption of that system of weights and measures which alone has any chance of becoming universal—the metric system." R. P. W.

DEPARTMENT OF ZOOLOGY.

NOTES.

Height of Birds in Migratory Flight.—Measurements of the heights of birds in nocturnal migration were made by a new method at the University of Illinois during the spring and autumn of 1905. The work was done by Professor Joel Stebbins, the astronomer at the university, assisted by Dr. F. W. Carpenter of the zoological department. The former has published a full account of his method, with the mathematical data and calculations, in the February number of "Popular Astronomy," while the latter has contributed to "The Auk" for April a more popular account of the results attained.

During the past twenty-five years the astronomical telescope has been used from time to time to penetrate, with more or less success, the mystery of the nocturnal migratory flight. By pointing the telescope toward the moon on clear nights in the seasons of migration, birds may often be seen as dark objects passing rapidly across the bright background. Some information has been secured in this way as to the number of the passing birds, and occasionally as to species, when characteristic shapes of body or peculiarities of flight have caught the eye of the trained ornithologist. Several attempts have been made to obtain, with the telescope, measurements of the elevation of the birds, a matter which has never been satisfactorily settled. Standard works on ornithology generally estimate the height at from one to three miles, basing these figures on the most satisfactory observations that have been recorded. All these attempted measurements have been made by the use of a single telescope, and have involved assumptions which could not be strictly verified.

Professor Stebbins' method is a decided improvement on ones previously in use. By making simultaneous observations of a bird through two telescopes, its "parallax," or angle at the bird subtended by the two observers, can be determined. With this as a basis and the necessary astronomical data it is possible to calculate with considerable accuracy the distance of the bird from the telescopes, and its height above the ground. The determination of the direction of flight also becomes possible.

The measurements made at Urbana show that the migrating birds were seldom as high as one-half mile above the ground. Out of eighteen birds whose heights were directly measured but one had an elevation of one mile. Three others were between one-half and one mile high, while the remainder were less than one-half mile above the ground, one being as low as twelve hundred feet. The upper limit of twenty-four birds seen on a night in October was ascertained to be sixteen hundred feet. The majority of the twenty-four were considerably below this height.

Earthworm Collecting Made Easy.—In Science of March 23, 1906, Professor Charles W. Hargitt calls attention to the use of irritating substances in solution, sprinkled on the surface of lawns and gardens

as a means of stimulating the worms to leave their burrows and crawl about where they are easily picked up. This is said to be a great improvement over the use of a lantern at night, or of the spade.

Rushmore's Concentrated Worm Destroyer, manufactured at Garden City, N. Y., and sold by the barrel for use on golf links, is one substance mentioned. It should be diluted with about 150 parts of water, and the worms placed in clean water as soon as possible and the water frequently changed to remove the harmful irritating substance. Corrosive Sublimate, one part in ten thousand of water and also a decoction of mustard are mentioned as accomplishing the same purpose. If solutions are too concentrated, the worms are said to retreat still further into their burrows. A little experimentation is likely to lead to the discovery of a number of materials that may be similarly useful.

Habits of Necturus.—Necturus has become so widely used as a laboratory animal that all information in regard to it is of interest to teachers of zoology. A paper on its habits in "The American Naturalist" for February, by Professor A. C. Eycleshymer, though containing little that is new, brings together in one place such facts as have been ascertained.

The mud-puppy "is found most abundantly in the rivers tributary to the Great Lakes and in the inland streams and small lakes of the adjoining states." While little is known concerning the environment to which the animals are adapted, they are usually observed in the spring and summer in quiet water from four to eight feet deep. They move about at night, retiring during the day to dark recesses beneath stones, boards or logs. The mating season appears to be in the autumn, and the eggs are laid in May beneath submerged objects to the under side of which they are attached. Their food consists largely of small crustaceans and insect larvæ and occasionally of small fish. They are known to eat the spawn of white-fish. Without any food whatever they seem to be able to live for months. The skin is probably a useful accessory organ of respiration, but the writer's evidence in favor of the functional importance of the lungs appears inconclusive.

Observations of Bird Migration.—The request for co-operation in a study of bird migration brought a favorable response from thirteen localities ranging from Ohio to Colorado and from Centralia, Ill., to Milwaukee, Wis., and Ann Arbor, Mich. It is very desirable that still others take hold of the work. Data concerning the extensive movements that always take place during the last week of April and the first week or two in May will be especially useful and the writer will be grateful for records of the dates of actual first arrivals of any or all of the following species: any thrushes, catbird, any warblers or vireos, purple martin, tanagers, rose-breasted grosbeak, orioles, crested flycatcher, kingbird, humming bird, chimney swift and cuckoos. More than an equivalent amount of data will be sent in exchange. Blanks for report may be had from Professor Frank Smith, University of Illinois, Urbana, Ill.

INSTINCT IN HUMMING-BIRDS.

By Avery E. Lambert,
Framingham, Mass.

A remarkable instance of instinct, as a result of inheritance, has recently come to my attention through a friend, who was the possessor of a small humming-bird.

Mr. J. S. Manter found a young humming-bird in the street, one morning, at Wellesley Hills, Mass. The bird was merely a tiny ball of down, being, as Mr. Manter says, "no larger than a bumble-bee." It had evidently fallen from its nest.

Taking the tiny creature to his home, Mr. Manter determined to do what he could to rear it as a pet; a plan which he was successful in accomplishing.

The bird was fed, in the first place, on honey which was presented in a spoon. It fed by thrusting its tongue into the honey repeatedly until satisfied. It grew rapidly, and soon attained adult proportions. One day, no honey being available, the bird was introduced to sugar dissolved in water. After trying this food it could not be induced to return to honey.

Hearing that humming-birds sometimes fed their young on mosquitoes, Mr. Manter caught some and presented them, with the result that they were not only refused, but the bird was apparently frightened by their presence in the box. Before it was able to help itself the young humming-bird would indicate the fact that it was hungry by making a peculiar noise, which Mr. Manter states was used only when it wanted food.

As the bird grew older, and was able to fly about it was given the freedom of the rooms occupied by the family. A supply of sweetened water was kept in a small saucer in a convenient place to which the bird would fly when hungry, feeding by rapidly protruding its long tongue into the liquid until satisfied.

One peculiar habit it had was that, when hungry, it would never approach the dish of sweetened water at once; but first flew rapidly about the room pecking at the flowers figured on the wall-paper. After doing this, it would fly to the dish and feed. This was its invariable habit before approaching the dish containing its food.

This instinct which recognized flowers in the figures on the wall-paper is remarkable on account of the fact that the bird was captured before it was old enough to have had experience of flowers, or any "instruction" which would lead to their recognition.

The first impulse leading to this recognition probably originated in the sense of hunger. The odor of the sweetened water may have contributed a quota of stimulus; but the principal element in the recognition was visual, backed by certain inherited cerebral mechanisms which are wont to react to the impressions derived from the color and form of flowers.

That such a capacity for the spontaneous recognition of flowers as a source of supply from which the bird's food was to be obtained is a matter of inheritance, rather than of "schooling," is clearly evident from the above incident.

SAN FRANCISCO MOUNTAINS—SANTA FE ROUTE

CHEMISTRY NOTES.

The manufacture of sugar and alcohol from wood is being carried out experimentally on a large scale by Dr. Roth of Breslau. His methods are based upon a carefully gauged effect of a very dilute mineral acid upon cellulose, together with high pressure and heat, and afterward an energetic "oxidation" with the infusion of ozone.

He produces from 100 kgs. of sawdust 15 to 17 liters of 80 per cent spirit, and by using hydrogen peroxide the production is now said to be raised to 24 liters. The cost of absolute alcohol by the Roth process is 8 to 10 pfennigs compared with 28 pfennigs for absolute alcohol obtained from potatoes or cereals.

If the new invention is applied to the manufacture of sugar, instead of spirit, the profits are even greater.

TYPICAL SCENE IN THE PETRIFIED FOREST

SOMETHING ABOUT EGGS.

The everyday world is full of wonderful things, yet when you give a moment's thought to an egg—well, a chemist would tell you it contains so much proteid, phosphoric acid and iron. But one should think of it as a

Treasure house, wherein lie
Locked by angels' alchemy
Milk and hair and blood and bone.

An egg contains in concentrated form everything that is required to develop a chicken, and it can be cooked in so many ways that it is palatable as well as digestible. That is why eggs are chief among the foods allowed an invalid. Though chemists have tried for a hun-

dred years to discover it, nothing in science or in all our wide variety of foods can be transformed into a substitute for eggs. Of course one could, if necessary, cook without them, only it would mean going without a score of dishes we think of as everyday necessities, such as custards, cake, puddings, griddle cakes, to say nothing of the abundant use of what we might call purely egg dishes.—*From The Delineator for March.*

NEEDLESS ALARM ABOUT FOOD ADULTERATION.

Writing in the March *Delineator*, Mary Hinman Abel, who is conducting *The Delineator's* campaign for safe foods, asserts that there has been much needless apprehension in regard to the danger to health from food adulterants. Note the list of falsifications that terrifies the householder, says Mrs. Abel, and you will find that most of them affect luxuries and food accessories, few of them can rank as necessaries, and all of them are consumed in small quantities. In publications on this subject there is often seen a list of some twenty articles which are said to adulterate ground spices; in it cocoanut shells, sawdust, and flour figure largely. This list spaces well in an article and is very telling. But if we can keep a sense of proportion, it is evident how unimportant this falsification is on the grounds of health. It is asserted that the yearly traffic in these articles is not equal to the nations' flour bill for three months. The two substances oleomargarine and glucose, that are responsible for the vast majority of false labels, are harmless to health, and the same may be said of cotton seed oil, which has been frequently sold as olive oil. At the worst, by no means all of even luxuries and condiments are falsified. In every town are to be found reliable dealers, those who are very intelligent about the source of their supplies, some of them being expert buyers, from whom no secrets are hidden. My own experience is that they are more than ready to give a truthful answer to questions. For most of us the use of average intelligence and care will safeguard us in this as in many other departments of practical life. If we have the good sense, either natural or acquired by sad experience, to avoid such foods as lobster salad when the thermometer is ranging in the nineties, we may go unharmed from season to season. Always provided that our milk and market inspection is what it should be, and the water uncontaminated.

The Fixation of Atmospheric Nitrogen. From the distillation of gas from coal, ammonia is one of the most useful by-products. This and the nitrate beds constitute the chief sources of nitrogen compounds and neither is inexhaustible.

There are nitrate beds in Spain, east of the Caucasus, and elsewhere; but practically all our soda-saltpeter comes from the Pacific coast of South America, from the rainless Atacama and Antofagasta districts, which, up to 1879 belonged partly to Bolivia, and partly to Chili, and which are now all Chilian territory.

The exports of Chilian saltpeter began about 1830; by 1875 they totaled 200,000 tons annually, and at the present time the annual exports have reached 1½ million tons. If the consumption should continue to increase at the same steady rate, the saltpeter stores will barely last another twenty years, according to Vergara's estimate. Broadly speaking it may be said that four-fifths of the Chili saltpeter is utilized in agriculture, while the remaining fifth is claimed by the chemical industry for the manufacture of nictric acid, nitrates, explosives, and various compounds.

Of late chemists have been eagerly looking for means of again utilizing the only inexhaustible nitrogen stores—those of our atmosphere. Cavandish and Priestley in 1781 and 1786 indicated the way when they observed electric sparks caused by the oxidation of atmospheric nitrogen to acid compounds. Since that time many attempts to prepare nitric acid and its salts by utilizing the nitrogen of the air have been made and one at least is a success commercially. This process of Birkeland and Eyde uses flame electrodes of the magnetic blow pipe type.

They have three furnaces now in operation at Notodden, Norway, which absorb 500 kilowatts each. The furnaces are cylindrical boxes suspended between two vertical uprights, to the ends of which the coils of the electromagnets are attached. The poles lie in the horizontal axis of the cylinder, and the two perpendicular arc electrodes are at right angles to them. The flame disk of each furnace has a diameter of more than two meters.

The air enters through ports on both sides of the disk, and is drawn off below, having passed right through the plane of the flame.

The electrodes are hollow copper rods, rounded off and closed at the ends; water circulates in them, and as the striking points of the arc are constantly being shifted by the magnetic deflection, the wear of the electrodes is inconsiderable.

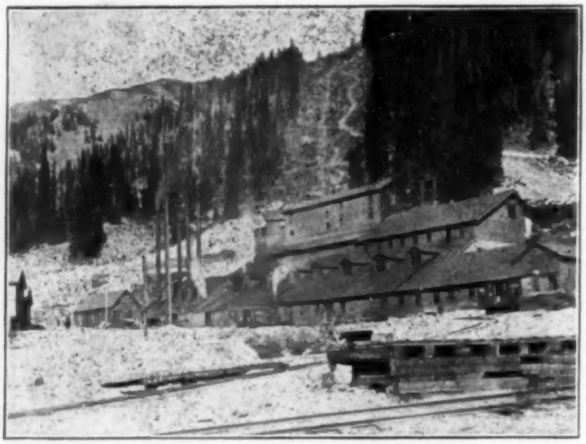
Electrodes have, in fact, been kept in uninterrupted use for hundreds of hours.

The air leaving the furnace contains not more than two per cent of NO, and passes first into the reaction or oxidation chambers, in which the gas current is checked in order to cool and to oxidize the NO to NO_2. That these reaction chambers must have ample dimensions, and that sufficient time must be allowed, is clear from Lepel's researches. The gas is then conducted to eight absorption towers, built up of granite and charged with quartz, in which the gas meets water.

The dilute acid flowing off below is again raised, and made to trickle down once more, until the contents of HNO_3 have risen to fifty per cent. Two more towers, irrigated with milk of lime, and further, a dry lime chamber, are added to absorb the last traces of acid. The obtained nitric acid is neutralized with limestone, and the calcium nitrate is evaporated and fused with the waste heat of the reaction chambers, and run into iron cases.

The average yield is now, at Notodden, from 500 to 600 kg. of nitric acid per kilowatt year. There is an abundance of water power which

it is estimated would be available at the low rate of $3 per year. Under these circumstances the good calcium nitrate produced at Notodden could certainly compete with the Chili saltpeter. The furnaces have converted 700 kilowatts for long periods without showing signs of wear. The calcium nitrate is not the best paying nitrate; but it gives a good fertilizer, especially in the novel modification of a basic salt, which forms a dry non-hygroscopic powder.—*Sci. Am. Sup.*



STAMP MILL AND SMELTER, COLORADO

USES OF PEAT.

Peat is competing with wood as fuel, and serves as raw material for textile manufacturers, paper, cardboard, etc., and recently, artificial timber and boards have been made of peat which are unequaled, on account of their fire-proof qualities.

With the help of natural water power and by the application of improved methods, on the lines of "Siemens Generator Gas" making, peat has been utilized for producing "peat gas."

The latest form of using peat as a fuel is by the Schwerin process, controlled by the Hoechst Color Works, the product being known as "Osmon."

The greatest difficulty in preparing peat fuel hitherto, has been the peculiar tenacity with which it retains its contents of water, amounting to 85 or 90 per cent.

This quantity is reduced through the osmon apparatus, by applying an electric current of 10 to 12 kilowatts, to one cubic meter of raw peat, to 65 or 70 per cent of water, and the remaining quantity of liquid is easily reduced to 15 per cent by air drying, the product being a substance very similar to brown coal. It can, the same as coal, be broken

up into lumps, thus avoiding the great drawback in briquettes, which are very apt to fall to pieces suddenly and to consume rapidly when burning.

The heating value of osmon greatly exceeds that of wood and is about equal to that of lignite. The system can also be used for making osmon coke from the peat residues after gas-making.

Osmon is a very cheap fuel, and its manufacture is especially to be recommended for countries with natural water-power for producing electricity.

The latest use found for peat is in textile manufacture and as an unsurpassed isolating material, in which latter capacity nothing can compete with it but cork, which, however, is inferior, because it easily tears and breaks, while peat consists of hollow, closely-packed cells filled with air and formed of "souberin," which has an enormous chemical resistance, and its fibre being filled with air makes it a very bad conductor of heat and consequently an ideal isolator.

Peat also has the advantage of being proof against decay, the process of rotting having already been gone through, and its contents of humin acids greatly assist its capability of absorbing ammonia gas.

The promising industry for working up peat can use the raw material without any fermenting processes or apparatus such as are necessary for spinning wool or cotton, thus preserving as much as possible its natural qualities.

Being a poor conductor of heat, and yet porous, perspiration-absorbing, and of light weight, blankets for men and horses are made of it, also carpets and rugs, peat wadding, isolating ropes, paper and cardboard.—*Scientific American Supplement.*

PRESERVATION OF MAIZE BY FUMIGATING WITH SULPHUR DIOXIDE. CLAYTON PROCESS.

The idea of using the Clayton apparatus and process, which has done excellent service in disinfection, extinguishing fires and destroying vermin, for preserving maize, occurred to Dr. Loir, and in his preliminary experiments on a small scale he proved that maize exposed for two hours to Clayton gas was entirely freed from living bacteria and remained in good condition, even if wet, for two months, while similar wet maize not so treated, spoiled in one month. The treatment also killed all insects without affecting the vitality of the maize, which sprouted vigorously. The first experiment on a large scale and in the conditions of commercial practice was made on the 6,000 ton steamer "Abergeldie," laden at Buenos Ayres with maize for Antwerp and London. Of the four compartments of the vessel only one, containing 2,000 tons of maize of all three grades was connected with the Clayton apparatus in the engine room and fumigated four times during the thirty-three days' voyage. This compartment, in marked contrast to the others, was always entirely free from insects and foul odors and on arrival at Antwerp its contents were in perfect condition.

There was not a trace of steam or of heating, which are certain indications of fermentation. One bag of maize, on which water had leaked, had sprouted as if to prove that it was uninjured by the treatment.

This experiment appears to have solved most satisfactorily the problem of the preservation of maize during transport and at the same time to have opened a new field of usefulness to the Clayton process.

The Clayton apparatus consists essentially of a gas generator, a motor, a Root blower, and a cooling device. In the generator, or furnace, the bottom of which is covered with sand, sulphur is burned on a series of grates. From the top of the generator a pipe runs, through the cooling apparatus, to the bottom of the blower. The compartment to be fumigated is connected with the apparatus by the pipe running from the top of the blower to a hole in the floor, and the pipe running from a hole in the wall connects with the bottom of the generator. By the operation of the blower the mixture of gases called Clayton gas, consisting of sulphur dioxide and other oxides and residual nitrogen, is drawn from the generator through the cooler and forced, at ordinary atmospheric temperature, into the compartment, the air of which is at the same time, driven through the pipe to the generator, where it is converted into Clayton gas.

The pipe leading to the generator may be put into communication with the external atmosphere by a valve, but this is opened only when the compartment contains inflammable gases, and for ventilation in the last stage of the process.

The apparatus is either installed permanently in the ship or brought alongside on the wharf, or on a lighter, as required. When fire is discovered in a compartment this, if not already in connection, is connected with the apparatus by hose, the sulphur in the generator is ignited by means of alcohol or kerosene, and the motor which drives the blower is started. The air of the compartment is thus drawn through the closed circuit of the apparatus until its free oxygen is so far exhausted by combination with sulphur that the fire is extinguished. Then the generator is cut out of the circuit and the heated gases continue to circulate through the compartment and the cooler until they are cooled to a safe temperature, when the valve is opened, the gases expelled and fresh air forced into the compartment.

It has been proved that burning petroleum, naphtha, turpentine, etc., can be extinguished almost instantly without danger of a second outbreak of fire, while with substances like cotton and hay, which retain much heat, the temperature must be reduced below 40° C (104° F.) before the external air can be gradually admitted with safety.

For the prevention of fire in very inflammable cargoes or such as are liable to spontaneous combustion the compartment is made airtight and Clayton gas is forced in until the air contains about 5 per cent of sulphur dioxide.

(Clayton gas contains more than 15 per cent while 4 or 5 per cent

is the most that can be obtained by burning sulphur in the compartment itself.)

For the preservation of maize, disinfection and destruction of rats and vermin, the process is the same as that above described. The suffocating gas drives rats and mice from their holes so that their bodies are easily accessible, which is not the case when they are killed by poison. The disinfecting action of the gas is increased by the heating of all the air of the compartment to 400° or 500° C in the generator. The disinfection of a steamer of medium size occupies from 8 to 12 hours.

Experiments with various cargoes prove that the process does little or no injury, if the ship is thoroughly ventilated after fumigation. On perfectly dry wares Clayton gas has no effect.

A few vegetable but no mineral dyes are affected by it. Fresh meat, fresh fruit, and some other articles of food absorb a little sulphur dioxide and polished metals are slightly dulled. Objects which are very sensitive to sulphur fumes can be protected by wrapping them lightly with porous paper.

There are other effects which are transient and removed by airing. The apparatus is suited to the disinfection of hospitals, barracks, and other buildings as well as ships.—*From Scientific American Supplement.*

INDIAN VILLAGE ON THE LINE OF THE SANTA FE

NOTES FROM THE UNIVERSITY OF ILLINOIS.

At the regular meeting of the Mathematical Club on February 10, Mr. G. A. Goodenough, assistant professor of mechanical engineering, spoke to the club on "What mathematics an engineer should know."

Professor Goodenough said that the mathematics an engineer needs depends upon the kind and quality of engineer considered; a civil engineer needs a kind somewhat different from a mechanical engineer; a high grade engineer needs much more knowledge of pure mathematics than a poor engineer. The *first class* engineer will know more mechanics and theoretical physics than he gets in the average engineering course. He will make himself better acquainted wtih the fields of abstract dynamics, thermodynamics, theory of electricity, differential equations, solid analytic geometry and the theory of alternating currents. All classes of engineers should know more about the theory of errors, fitting curves to observation data, and projective geometry.

Some things now taught to engineers should be more strongly emphasized. Civil engineers are specially concerned in the solution of triangles while other engineers are more in need of the analytic side of trigonometry. In the calculus more work should be done in functions of two variables with their corresponding physical interpretations. Engineers have little use for the theory of singular points and other singularities. Less time should be spent upon learning how to integrate and very much more time should be spent upon the applications of the integral calculus; particular integrals values may often be obtained from tables but there is no substitute for ability to apply the theory for problems in hand.

Too many engineering students are very poor calculators. They cannot use logarithms well. They are not acquainted with well known short cuts and contracted processes. They show little judgment in checking results for sensible results. More training should be given in checking equations for homogeneous units.

The engineer has little interest in the exceptional cases which the pure mathematician studies. He is concerned primarily with problems taken from actual conditions in nature and he seldom if ever meets discontinuous functions, non-converging series, non-derivitive curves and such singularities which the pure mathematician points out as possibilities. Professor Goodenough expressed the belief that such singularities do not occur in nature.

At the meeting of the Mathematical Club on February 24, Dr. Coar, instructor in mathematics, presented a paper on the construction of conics by the use of the straight edge when some of the elements are imaginary. Dr. Coar called attention to the well known fact that five points determine a conic, and showed how, if all these points are real, to construct with the ruler alone any number of additional points on the conic. He then took up the cases when two and four of the five points are imaginary, and showed that it is, in this case, also a simple matter to construct any number of additional points on the conic. In addition to these constructions, the literature of the subject was reviewed.

ERNEST B. LYTLE.

CORNELL UNIVERSITY.

There are many teachers who are now making plans to attend a summer school, yet are undecided what school or university they will select. Theré are two things which the summer school student takes into consideration before deciding what institution he will attend, namely the standing of the institution and the general surroundings. The summer student does not expect to spend all of his time in labor but will take part of the time at his disposal for recreation. The school which will be selected, then, is the one which combines quality of instruction and pleasant surroundings.

Of the many schools offering courses this coming summer there are none which offer better ones, as to the extend and variety, and standing of the faculty, than does Cornell University, at Ithaca, New York. In beauty of location there is no institution of its class to compare with it. Its situation is acknowledged by all to be unsurpassed by any in the country.

In all sciences, mathematics and manual training the courses offered are exceptionally strong. The many departments of science are especially well equipped for carrying their work. In manual training the shops and drawing rooms of Sibly College are the largest and best equipped in the country. They are thrown open to the students of the summer session. In fact the equipment and facilities of the entire university are at the disposal of members of the summer school. Any one contemplating a course in a summer school cannot do better than to connect himself with one or more courses in this institution. Send to the Director of the Summer Session for an announcement.

REPORTS OF MEETINGS.

PENNSYLVANIA ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

At a meeting held Monday evening in the Science Lecture Hall of the Warren High School building a permanent organization of the Pennsylvania State Association of Science and Mathematics Teachers was effected. The constitution submitted by the committee appointed for the purpose was adopted and the following officers were elected: Prof. J. J. Quinn, Warren, president; Principal Frank Hemnion Irvine, vice-president and chairman of mathematics section; Prof. A. E. Ricksecker, Warren, vice-president and chairman of science section; Principal C. S. Knapp, North Warren, secretary; and Principal C. M. Freeman, Tidioute, treasurer. It is the intention of the society to hold a convention in Warren about the first of May. Notice of the exact date will be given as soon as all the arrangements are perfected.

MEETING OF THE PHYSICS AND CHEMISTRY SECTIONS OF THE MICHIGAN SCHOOLMASTERS' CLUB.

The chemical conference was held Thursday afternoon, March 29, in lecture room B of the Michigan University chemical laboratory. The meeting was called to order at 1:45 P. M. by the vice-chairman, F. C. Irwin, Central High School, Detroit.

The following program was presented:

1. The Equivalent Weight of Magnesium,
   Mr. E. A. Clemans, Central High School, Detroit.
2. Address: Are the Elements the Ultimate Constituents?
   Professor S. L. Bigelow, University of Michigan.
3. The Chemistry of the Bread We Eat,
   Mr. De Forrest Ross, Ypsilanti High School.
4. The Reference Library in Chemistry,
   Professor B. W. Peet, State Normal College.
5. A Series of Combining Weight Determinations,
   Mr. J. W. Matthews, Western High School, Detroit.
6. A Method of Classifying the Inorganic Acids for Analysis,
   Professor W. S. Leavenworth, Olivet College.

The physical conference was held Friday and Saturday afternoons in the new lecture room of the University physical laboratory. The chairman, Dr. H. M. Randall of the University of Michigan, called the meeting to order. The following program was rendered:

FRIDAY AFTERNOON.

1. An Experiment in Thermal Conductivity,
   Mr. H. L. Curtis, Michigan Agricultural College.
2. The Use of the Alternating Current in the High School.
   Mr. H. L. Parrott, Saginaw.
3. Alternating Current Experiments,
   Mr. A. O. Wilkinson, Western High School, Detroit.

4. Address: The South African Meeting of the British Association for the advancement of Science (illustrated by stereopticon),
   Professor Henry S. Carhart, University of Michigan.
5. The Entrance Requirements in Physics and its Relation to the Physics of the College Course,
   Professor N. F. Smith, Olivet College.
   Professor C. W. Green, Albion College.
6. Boyle's Law Apparatus,
   Mr. C. D. Carpenter, Michigan State Normal College.

SATURDAY AFTERNOON.

1. A Model for an Adjustable Cross-bar for a Laboratory Table,
   Mr. C. M. Bronson, Toledo, Ohio.
2. The Undercooling of Acetic Acid,
   Mr. C. F. Adams, Central High School, Detroit.
3. The Nerst Lamp in the Laboratory and Simple Experiments on Radio-Activity,
   Professor Fred N. Gorton, Michigan State Normal College.
4. A Convenient and Inexpensive Adjustment for a Galvanometer Scale,
   Mr. W. H. Hawkes, Ann Arbor High School.
5. A Simple Apparatus for Parallel Forces,
   Mr. De Forrest Ross, Ypsilanti High School.
6. An Apparatus for the Parallelogram of Forces,
   Mr. M. A. Cobb, Lansing High School.
7. Apparatus for Demonstrating Laws of Fluid Pressure,
   Mr. H. C. Krenerick, Berwyn, Ill.

It was voted that the chemical conference should be separate from the physical conference and that hereafter a separate chairman be elected for each body with equal rank. SCHOOL SCIENCE AND MATHEMATICS was recognized as the official organ of both conferences.

A FALLEN MONARCH, MARIPOSA GROVE, CALIFORNIA

NOTE ON THE NEW MOVEMENT AMONG PHYSICS TEACHERS.

The Committee of the Central Association of Science and Mathematics Teachers regrets much that it is not yet able to report the complete returns from the circular letter sent out by it. Up to the time of going to press 295 answers to this circular have been received. As far as counted, the vote on the list of experiments shows that the following are at present favored by at least two-thirds of those voting: 1. Weight of unit volume. 2. Lifting effect of water on body immersed in it. 3. Specific gravity of a solid heavier than water. 4. Specific gravity of a block of wood with a sinker. 7. Specific gravity of a liquid. 8. The straight lever. 13. Three forces in one plane applied at one point. 26. Pendulum. 28. Boyle's Law. 30. Barometer. 36. Testing a mercury thermometer. 37. Linear expansion of solid. 41. Specific heat. 42. Latent heat of ice. 57. Wave length of sound by resonance. 62. Phenomena of magnetism. 63. Magnetic field with iron filings. 66. Single-fluid cell. 70. Induced currents. 71. Resistance by substitution. 72. Wheatstone Bridge. 84. Phenomena of optics. 88. Index of refraction of glass. 91. Focal length of a converging lens. 93. Shape and size of an image formed by lens. 100. Photometry.

The complete returns will be issued in circular form early in May. Since sending out the circular other associations have become interested in the work, and several have appointed committees to coöperate in it. The second circular will therefore be issued by joint action of several committees. Anyone who has not answered the first circular, but who wishes to receive the further documents connected with this work, is invited to send a request for the same to the committee.

C. R. MANN, *University of Chicago.*
C. H. SMITH, *Hyde Park High School, Chicago.*
C. F. ADAMS, *Central High School, Detroit.*

IRRIGATIOZ BRIDGE

BOOK REVIEWS.

The Universal Kinship. J. Howard Moore. Charles H. Kerr & Co., Chicago, Ill. 14x19.5 Cm. 330 pages.

The chief purpose of the book, as stated in the author's preface, is to prove and interpret the kinship of the human species with the other species of animals. Physical kinship is the topic treated in the first hundred pages, in which the author presents evidence for a belief in the origin of the similar physical characters of man and other animals, by evolution. One hundred and forty pages are given to the evidence for the assumption that the psychical characters of man and the lower animals are also products of evolution, and that differences in the psychical activities of man and higher animals are simply differences in degree of development and not differences in kind. The remainder of the book is devoted to a study of the ethical kinship and here also the reader is directed to evolution for an explanation of the origin of the ethics of civilized men and savages from the lower animals. "The antecedents of human ethics and society are, therefore, to be looked for in the ant hill and the jungle."

The author is an ardent advocate of the application of the golden rule, not only amongst men but also between men and other animals and is thus led to make as much as possible of all evidence of their actual kinship. In his use of evidence he is, therefore, the zealous advocate rather than the unbiased judge. The reader who gets from this book his first ideas of the evidence for evolution of animals, will experience something of a shock when he later reads such a work as Morgan's Adaptation and Evolution, and finds how much uncertainty surrounds much of the matter which he had previously seen assumed as unquestionably true and hence used as positive evidence.

In spite of some unwarranted statements, especially in the first division of the book, there is much that is of real interest and merit.

Laboratory Manual of Chemistry for Secondary Schools. By W. A. Morse and F. C. Irwin. D. Appleton & Co., 1905.

This is one of the best books for its purpose that has ever been brought to our notice. The pupil following it will have to use his head as well as his hands and is not likely to refer to the course as easy or "a snap." The directions are very clear and interest is added by introducing problems, review questions, a brief consideration of Work, Energy, The Kinetic Theory of Gases, Methods of Determining Molecular and Atomic Weights, the Periodic System, Laws of Oxidation and Reduction, etc., descriptive matter not usually seen in laboratory manuals. The course is intended for those who have not had a previous course in physics.

An appendix considers briefly the significance of ions, dissociation, principles of precipitation, and an outline for the qualitative analysis of metals. The book was considered, by its authors, to be worthy of an index; a fact that will be appreciated by users of it.

The book is well printed, and contains few typographical errors. The experiment on Volumetric Composition of Water Vapor (21) and

the composition of ammonium chloride (65) and ammonia (66) do not seem to the reviewer feasible for large classes because of the complex apparatus in the first, and the use of considerable quantities of mercury in all three.

A balance which turns with 2 m. g. is recommended for the work, page 2, but in drying $CuSO_4$, p. 28, the pupil is directed to heat until weight is constant to .0005 g.

In experiment 66, to show the volumetric composition of ammonia, after the dry gas is in the eudiometer and temperature noted, something more than "then make the readings" should be given. In teacher's experiment 56 the size of the combustion tube is not indicated, nor is anything said of the change in volume of HCl due to the mere *pouring in* of the amalgam. The advantage of this experiment over the familiar one in which a U shaped eudiometer is used is not apparent to the writer.

The ratio of the weight of a given volume of water to the weight of an equal volume of iron does not represent, as indicated at top of page 25, how many *times heavier* one is than the other. A. L. S.

A Text-Book of Botany. By John M. Coulter, Professor of Botany in the University of Chicago. D. Appleton & Co., New York. 1906.

The ever-present question of the content of elementary botanical teaching is again brought to our attention by the appearance of this new text-book by Professor Coulter. Like its predecessor, "Plant Studies," it is a reading book to be placed in the hands of the student, to furnish an outline of the course and those concepts of plant life which the author believes to be essential to botanical instruction. It certainly furnishes a most admirable basis for field and laboratory work, and unlike most other texts it allows that freedom in the selection of materials for demonstration and student investigation which the reviewer believes to be essential to good teaching. The possibilities of laboratory and field work are so variable and so intimately connected with local conditions, that a book which provides the pupil with what is in large part a teacher's manual—as a large number of our texts do—places both the teacher and the pupil at a disadvantage. This difficulty is obviated in the present instance by supplying field and laboratory manuals under separate covers.

The structure, function and ecological relations of the organs of the seed plants are discussed in the first five chapters. As compared with "Plant Studies" this portion of the book has been greatly improved by the introduction of many new topics and illustrations.

The morphological relationships and the principles of classification of plants dominate the thought of the next thirteen chapters. The greatest innovation of the book occurs in this section. In discussing the great groups of plants, special attention is paid to the species which are of economic interest. There are also included three-page chapters on "Forestry" and "Plant-breeding." There is sure to be a difference of opinion as to the necessity and value of such abridged statements of important economic phases of botany, in an elementary

course. The reviewer believes that the attention of the pupils should be called to these subjects, but that they had better be referred to more adequate accounts to be found in magazines and government reports, which are always available to the live teacher. On the other hand there can be no doubt but that the relation of plants to man is an important and instructive part of botany. It adds interest to the subject and can be made to have the same educational value as those topics which are of purely theoretic interest. In so far as the paragraphs on important economic species meet this requirement they may be looked upon as a real contribution to the subject matter.

The last four chapters give an account of the commoner plant-associations which make up vegetation.

The clear and interesting style of the author, the excellence of the typography, and the wisdom shown in the selection of the illustrations combine to make this a valuable addition to the pedagogical resources of the subject.

E. N. Transeau, Alma College, Alma, Mich.

Science and Hypothesis. By H. Poincaré, Member of the Institute of France. Authorized translation by George Bruce Halsted, Ph. D., F. R. A. S., Kenyon College, Gambier, Ohio, with a special Preface by H. Poincaré and an Introduction by Professor Josiah Royce, Harvard University. New York, Science Press, 1905.

This work, which has attracted much attention in the scientific world since its first appearance, is now accessible to English readers who read neither French nor German. In view of the notices of the original work and the German translation which have appeared in recent scientific journals it will suffice here to give a summary of the contents and to note the conclusions reached on one or two points: Author's Preface, Introduction by Royce, Introduction. Part I. Number and Magnitude: Ch. I, on the Nature of Mathematical Reasoning. Ch. II, Mathematical Magnitude and Experience. Part II, Space: Ch. III, The Non-Euclidean Geometries. Ch. IV, Space and Geometry. Ch. V, Experience and Geometry. Part III, Force: Ch. VI, the Classic Mechanics. Ch. VII, Relative Motion and Absolute Motion. Ch. VIII, Energy and Thermodynamics. Part IV, Nature: Ch. IX, Hypothesis in Physics. Ch. X, The Theories of Modern Physics. Ch. XI, The Calculus of Probabilities. Ch. XII, Optics and Electricity. Ch. XIII, Electrodynamics. Appendix: The Principles of Mathematical Physics.

The nature of mathematical reasoning lies preëminently in mathematical induction. A complete induction involves an infinity of logical steps; the conclusion, however, is irresistible "because it is only the affirmation of the power of the mind which knows itself capable of conceiving the indefinite repetition of the same act when once this act is possible."

In the genesis of geometry the part played by experiment is indispensable; but geometry is not, "even, in part, experimental." Experience guides in the choice of a geometry [Euclidean, Riemaunecen,

etc.,] by pointing out, not the "truest," but "the most *convenient*." The axioms of geometry are "*conventions*," "*merely disguised definitions*," likewise chosen under the guidance of experience.

In physics hypotheses are admittedly indispensable. They are of three types: the practically unavoidable; the "neutral;" and "the real generalizations." Only the third class are capable of being tested by experiment and change with the progress of the science; the first give a permanent element to the theories of physics. The second may vary at the dictates of convenience without affecting the final result.

The book will interest not only teachers of mathematics and physics but also those concerned with the philosophical aspect of these sciences. The movement to translate into English important foreign scientific works is a gratifying sign of the increasing intellectual activity along scientific lines. The appearance of the name of Dr. Halsted as the translator is sufficient guarantee that the translation is both accurate and elegant. The translation is, of course, a most valuable addition to English scientific literature. The book contains approximately 200 pages, is well and clearly printed, and well bound.

T. E. M.

BOOKS RECEIVED.

The Art of Geometry. A Laboratory Manual for Students' Use, to accompany any text-book. By Arthur Latham Baker, Ph.D., Manual Training High School, Brooklyn, N. Y. Pp. 48. Sibley and Co., Boston.

Geology. By Thomas C. Chamberlin and Rollin D. Salisbury, University of Chicago. Vol. II. Earth History, Genesis, Palezoic. Pp. 692. Vol. III. Earth History, Mesozoic, Cenozoic. Pp. 624. Henry Holt and Co., New York. $8.00 net.

AMERICAN BOOK COMPANY:

Commercial Geography. By Henry Gannett, Carl L. Garrison and Edwin J. Houston. Pp. 445.

Elementary Algebra. By J. H. Tanner, Cornell University. Pp. 364.

Advanced Arithmetic. Elmer A. Lyman, State Normal School, Ypsilanti, Michigan. Pp. 253.

Exercises in Solid Geometry. By Levi L. Conant, Worcester Polytechnic Institute. Pp. 124.

First Year in Algebra. By Frederick H. Somerville. William Penn Charter School, Philadelphia. Pp. 208.

Exercises in Algebra. By Edward R. Robbins and Frederick H. Somerville, William Penn Charter School, Philadelphia. Pp. 173.

Elementary Mechanics. By George A. Merrill, Director of the Wilmerding School of Industrial Arts, San Francisco. Pp. 267.

Elements of Descriptive Geometry. By Charles E. Ferris, University of Tennessee. Pp. 127.

Measurements of Magnetism and Electricity. By George A. Hoadley, Swarthmore College. Pp. 111.

First Principles of Agriculture. By Emmet S. Goff, University of Wisconsin, and D. D. Mayne, Principal School of Agriculture, St. Anthony Park, Minn. Pp. 256.

WISCONSIN UNIVERSITY.

The science and mathematics courses offered by the University of Wisconsin Summer Session should attract the attention not only of students desiring higher degrees but of progressive teachers in our high schools. Professor Snow, whose reputation as an originator of new methods in the teaching of physics in secondary schools is second to none in the country, gives a course of thirty lectures upon mechanics and heat, electricity and magnetism, acoustics and optics. These lectures are fully illustrated by experiments upon which Professor Snow has lavished a great amount of money and time. A course is given in laboratory practice, designed to supplement these lectures. Professor Brigham of Colgate gives two courses in physiography, specially designed for teachers. Professor Frost lectures on hygiene for schools and Professor Harper gives a general course in botany. These general courses are supplemented by many advanced courses. Teachers who desire to escape from the city for summer work should consider the advantages of Wisconsin.

PUBLISHERS' NOTICES.

Owing to the terrible calamity which has befallen the city of San Francisco the National Educational Association Meeting for 1906 has been postponed until the year 1907.

The matter in this issue was all in print before the earthquake occurred. We are asking our readers to overlook the references to the proposed N. E. A. Excursion.

Any of our subscribers who may be in arrears for their subscriptions are earnestly requested to send us the amount of their indebtedness at the earliest convenience. We are obliged to meet our printing and other bills each month, with cash. Pardon us for calling attention to this matter, but we do need the cash.

SCIENCE AND MATHEMATICAL SOCIETIES.

Under this heading is published each month the name and officers of such societies as furnish this information.

Central Association of Science and Mathematics Teachers.

President, Otis W. Caldwell, State Normal School, Charleston, Ill.
Secretary, Chas. M. Turton, 440 Kenwood Terrace, Chicago, Ill.
Treasurer, Chas. W. D. Parsons, 320 Main St., Evanston, Ill.

Annual meeting Friday and Saturday immediately following Thanksgiving.

Chicago Center, C. A. S. and M. T.

President, W. C. Hawthorne, Central Y. M. C. A., Chicago.
Vice-President, P. B. Woodworth, Lewis Institute, Chicago.
Secretary, C. E. Osborne, High School, Oak Park, Ill.

North Eastern Ohio Center, C. A. S. and M. T.

President, C. W. Sutton, Central High School, Cleveland.
Vice-President, J. Cora Bennett, East High School, Cleveland.
Secretary-Treasurer, J. E. Crabbe, Glenville High School, Cleveland.

Association of Ohio Teachers of Mathematics and Science.

President, W. H. Wilson, Wooster University, Wooster.
Vice-president, T. Otto Williams, High School, Circleville.
Secretary, Thomas E. McKinney, Marietta.
Assistant Secretary, M. E. Grober, Heidelberg University, Tiffin.

New York Chemistry Teachers' Club.

President, Jesse E. Whitsit, DeWitt Clinton High School.
Vice-President, William J. Hancock, Erasmus Hall High School.
Secretary, Joseph S. Mills, High School of Commerce.
Treasurer, F. C. Dudley, Brooklyn Polytechnic Institute.

Missouri Society of Teachers of Mathematics.

President, H. C. Harvey, Kirksville.

Vice-President, L. M. Defoe, Columbia.

Secretary, L. D. Ames, Columbia.

Executive Council: E. R. Hedrick, Columbia, chairman; B. T. Chase, Kansas City; B. F. Finkel, Springfield; B. F. Johnson, Cape Girardeau; Wm. Schuyler, St. Louis; Miss E. J. Webster, Kansas City.

The Physics Club of New York.

President, Albert L. Arey, Girls' High School, Brooklyn.
Vice-President, R. H. Cornish, Wadleigh High School, New York City.
Secretary, Frank J. Arnold, Erasmus Hall High School, Brooklyn.
Treasurer, Robert H. Hopkins, Curtis High School, New Brighton, Staten Island.

Indiana Science Teachers' Association.

President, Lynn B. McMullen, Shortridge High School, Indianapolis.

Vice-President, Earl E. Ramsey, High School, Fort Wayne.

Secretary and Treasurer, J. F. Thompson, High School, Richmond.

Mathematical and Physical Section of the Ontario Educational Association.

Hon. President, W. J. Robertson, Collegiate Institute, St. Catherines.

President, C. A. Chant, University of Toronto.

Vice-President, H. S. Robertson, Collegiate Institute, Stratford.

Secretary-Treasurer, R. Wightman, Jarvis St. Collegiate Institute, Toronto.